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Yanagisawa

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(54) **ELECTRONIC TIMEPIECE WITH INTERNAL ANTENNA**

(71) Applicant: **Seiko Epson Corporation**, Tokyo (JP)

(72) Inventor: **Toshiaki Yanagisawa**, Suwa (JP)

(73) Assignee: **Seiko Epson Corporation** (JP)

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G04G 17/04 (2006.01)
G04R 20/04 (2013.01)

(52) **U.S. Cl.**
CPC ***G04R 60/10*** (2013.01); ***G04G 17/045*** (2013.01); *G04R 20/04* (2013.01)

(58) **Field of Classification Search**
CPC G04R 60/10; G04R 60/12; G04B 29/00; G04B 29/02; G04B 29/022; G04B 37/00; G04B 37/0008
See application file for complete search history.

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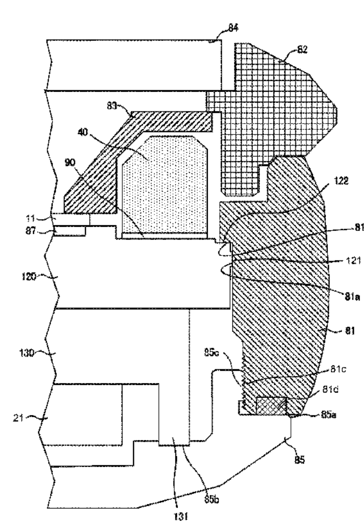
Primary Examiner — Amy Cohen Johnson
Assistant Examiner — Jason Collins
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An electronic timepiece has a main plate **120** for a movement **110** that drives a time display unit inside an outside case **80**; an annular antenna **40** housed inside the case **80** and positioned relative to the main plate **120**; and aback cover **85** that engages the case **80**. A circuit bridge **130** disposed below the main plate **120** has an upward pressure part **131** that pushes the main plate **120** to the time display unit side when the case **80** and back cover **85** are engaged. The main plate **120** has a movement top positioning part **122** that contacts the vertical positioning surface and positions the main plate **120** vertically to the case **80** when the main plate **120** is lifted toward the time display side by the upward pressure part **131**.

11 Claims, 14 Drawing Sheets



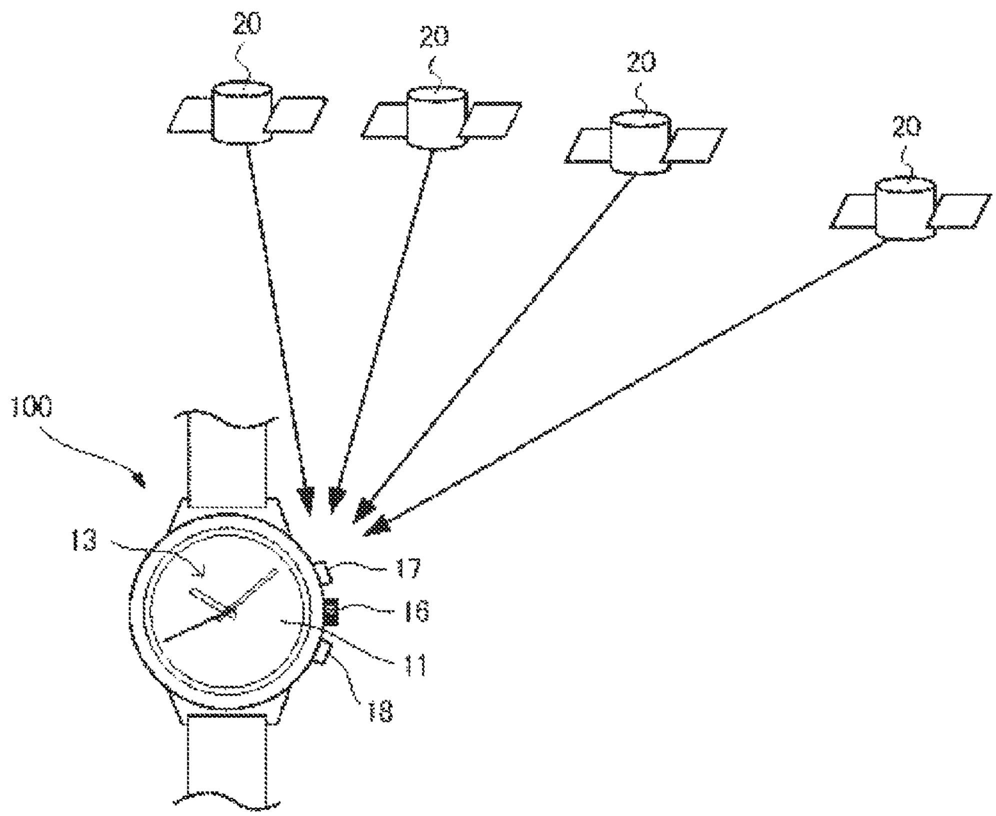


FIG. 1

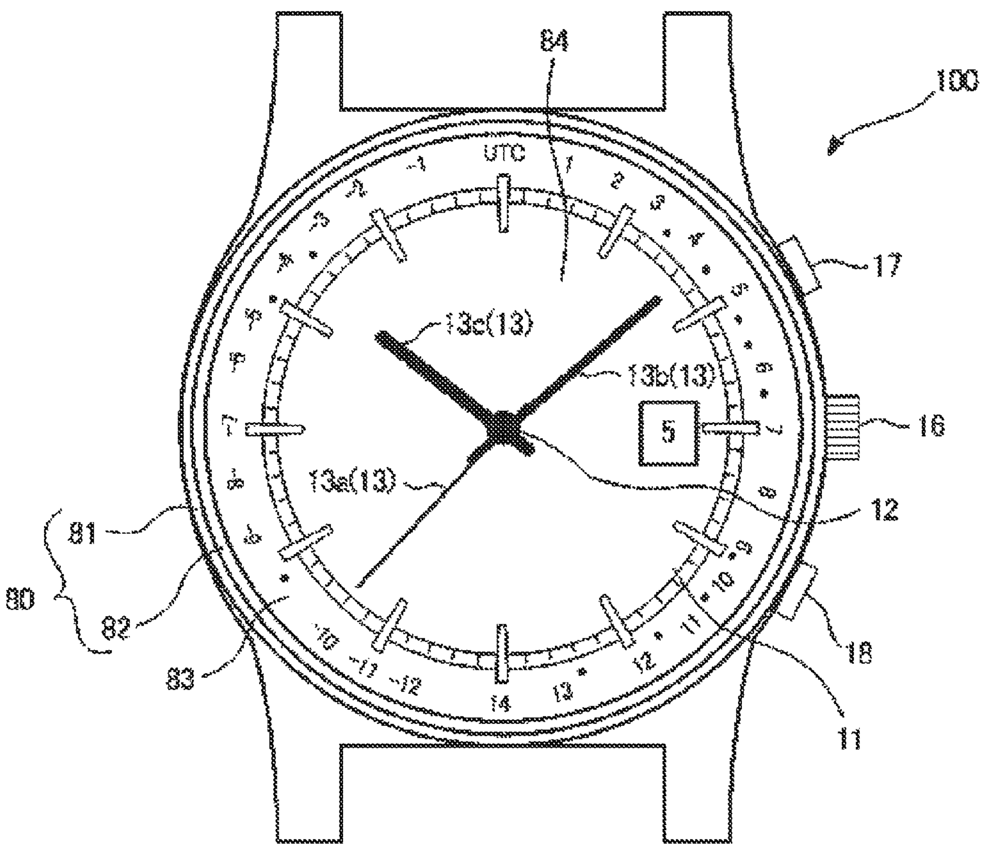
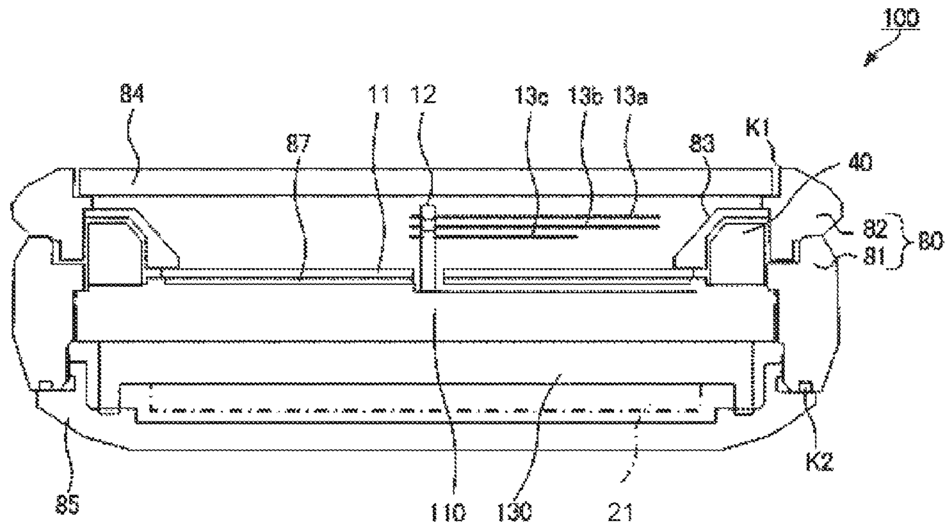


FIG. 2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84
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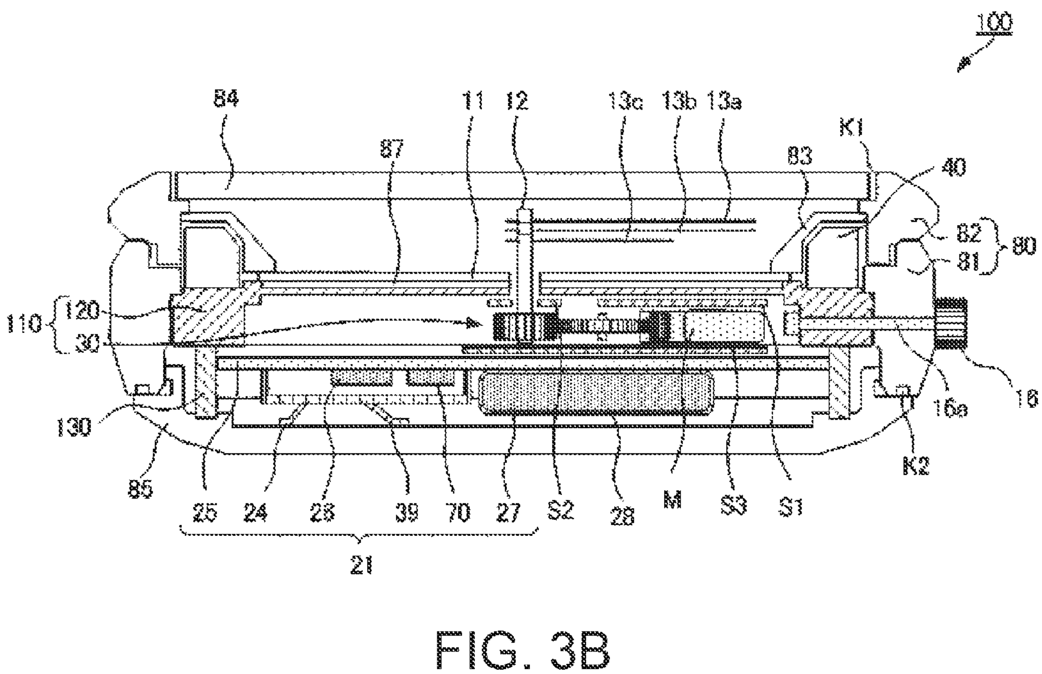
K2

FIG. 3A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39
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S2
28
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16a
16
K2
21

FIG. 3B

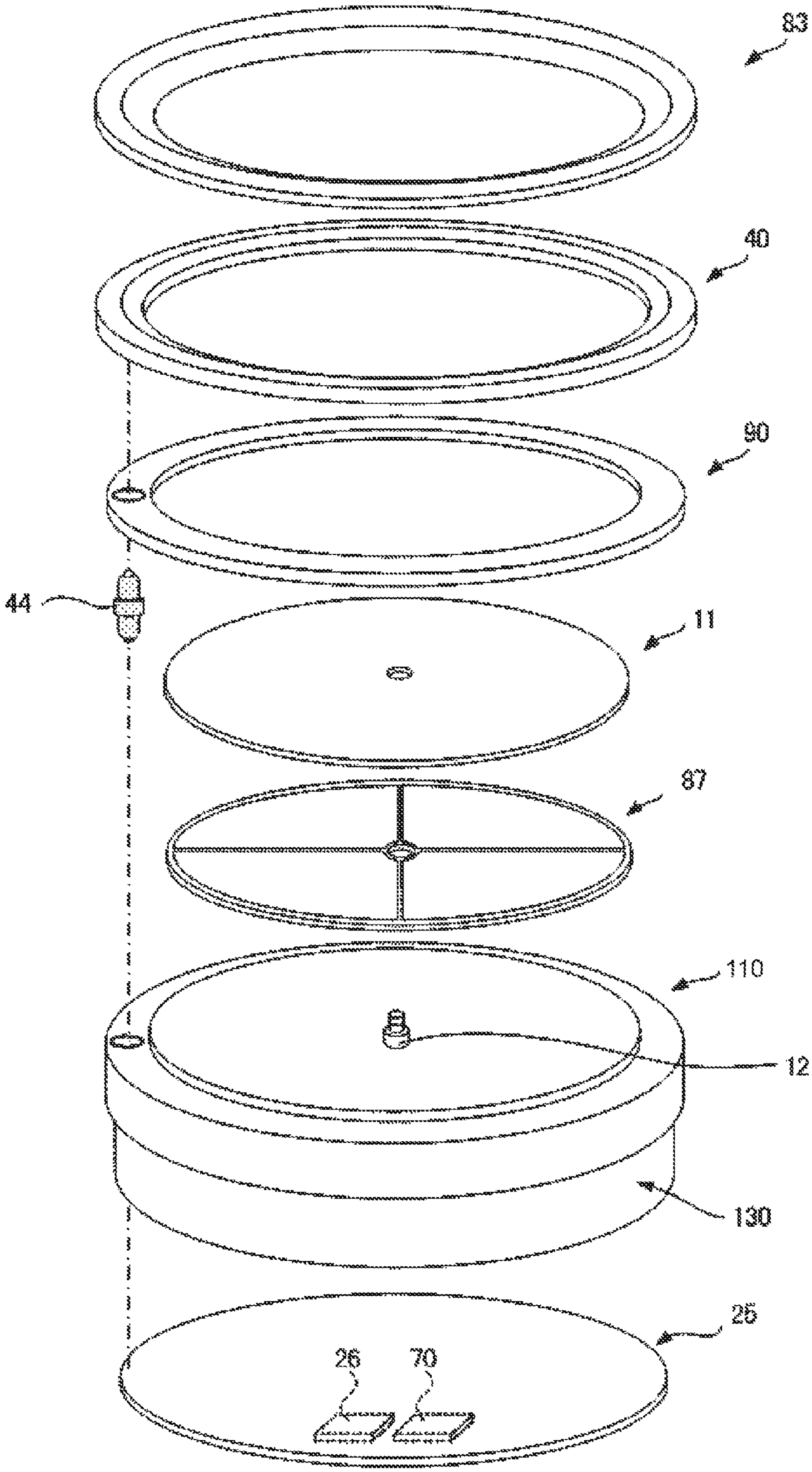
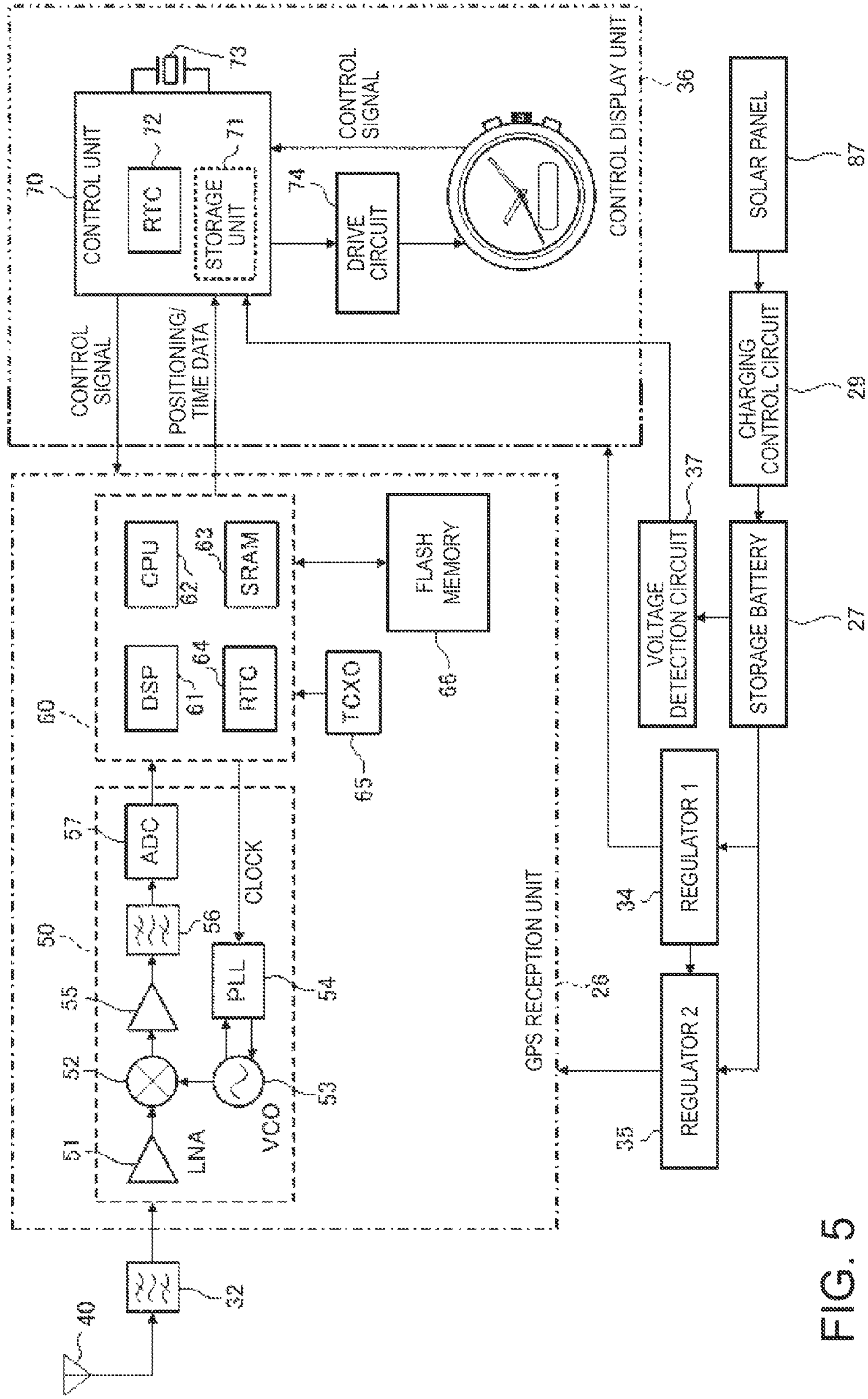


FIG. 4


CONTROL UNIT
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STORAGE UNIT
DRIVE CIRCUIT
CONTROL SIGNAL
CONTROL DISPLAY UNIT
POSITIONING/ TIME DATA
CPU
SRAM
DSP
RTC
FLASH MEMORY
TCXO
ADC
CLOCK
PLL
VCO
LNA
GPS RECEPTION UNIT
SOLAR PANEL
CHARGING CONTROL CIRCUIT
VOLTAGE DETECTION CIRCUIT
STORAGE BATTERY
REGULATOR 1
REGULATOR 2
70
72
71
73
74
36
60
61
62
63
64
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32
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87
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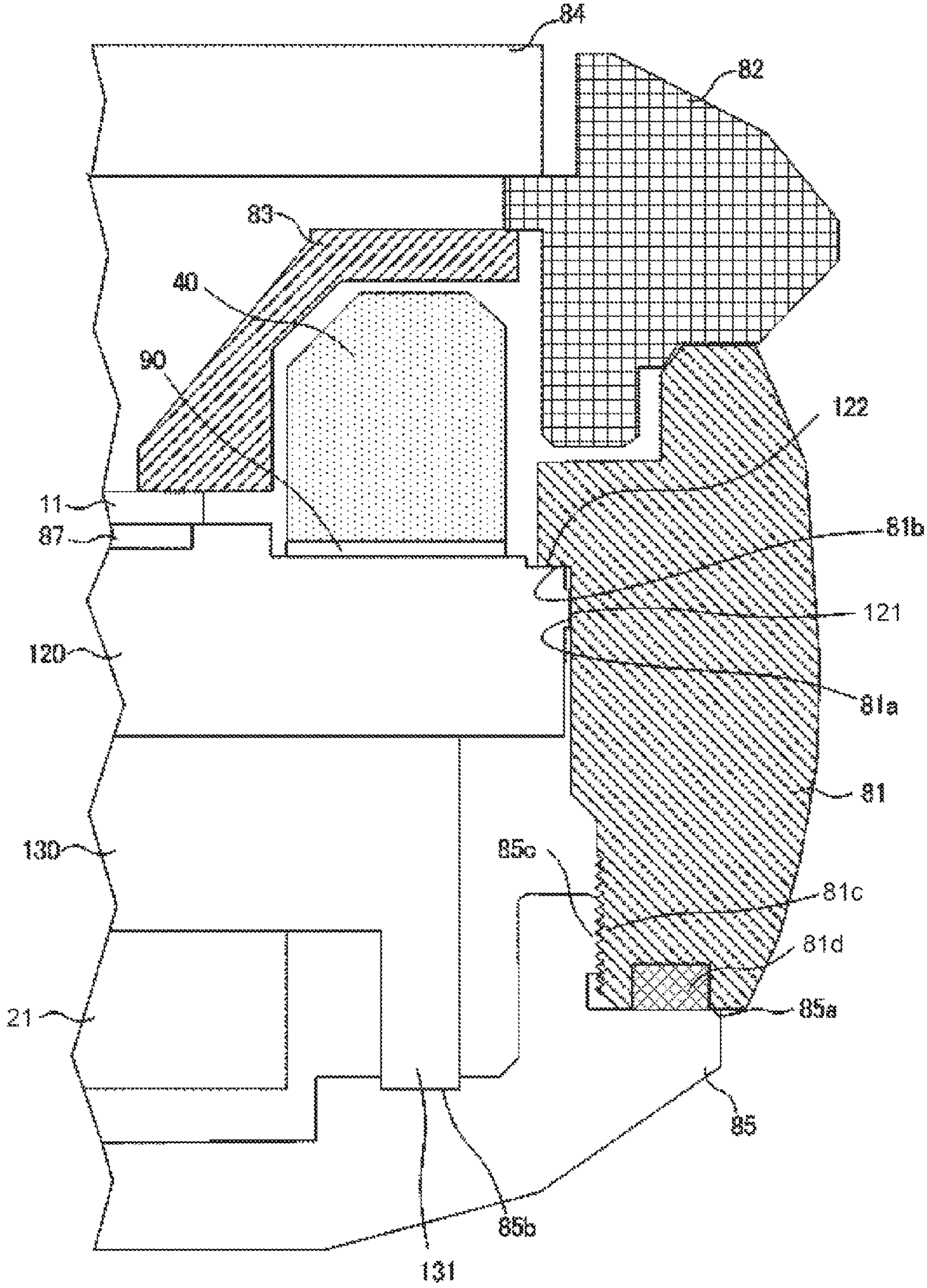
27

FIG. 5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85
85b
131

FIG. 6

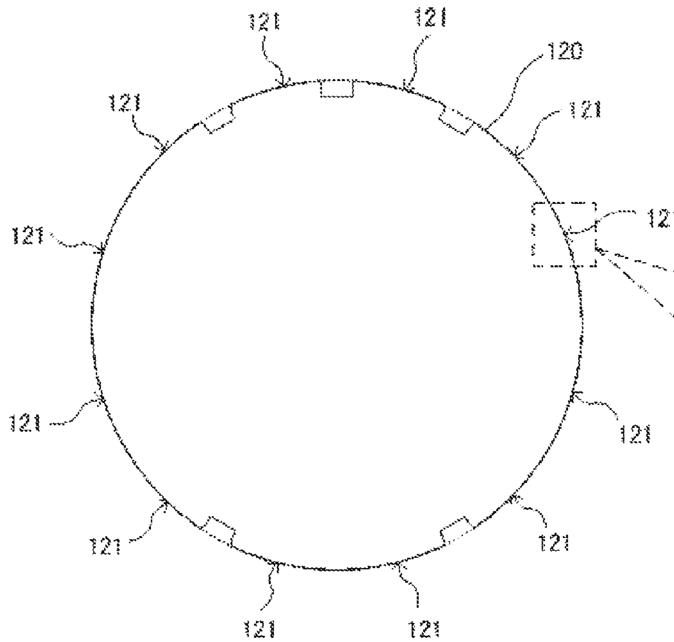


FIG. 7A

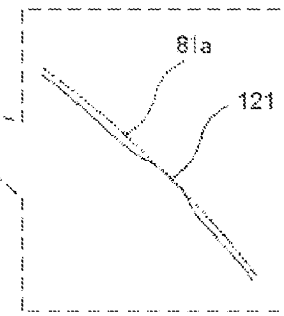


FIG. 7B

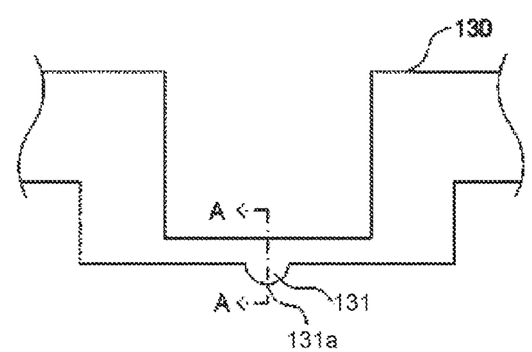


FIG. 8A

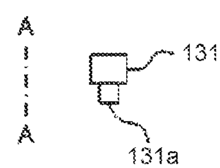
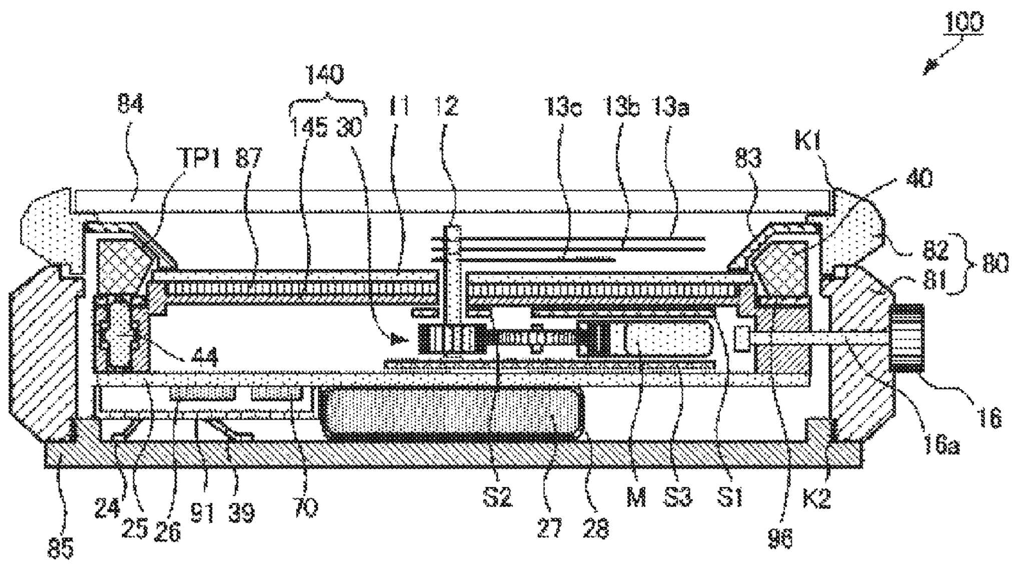


FIG. 8B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TP1
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44
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16a
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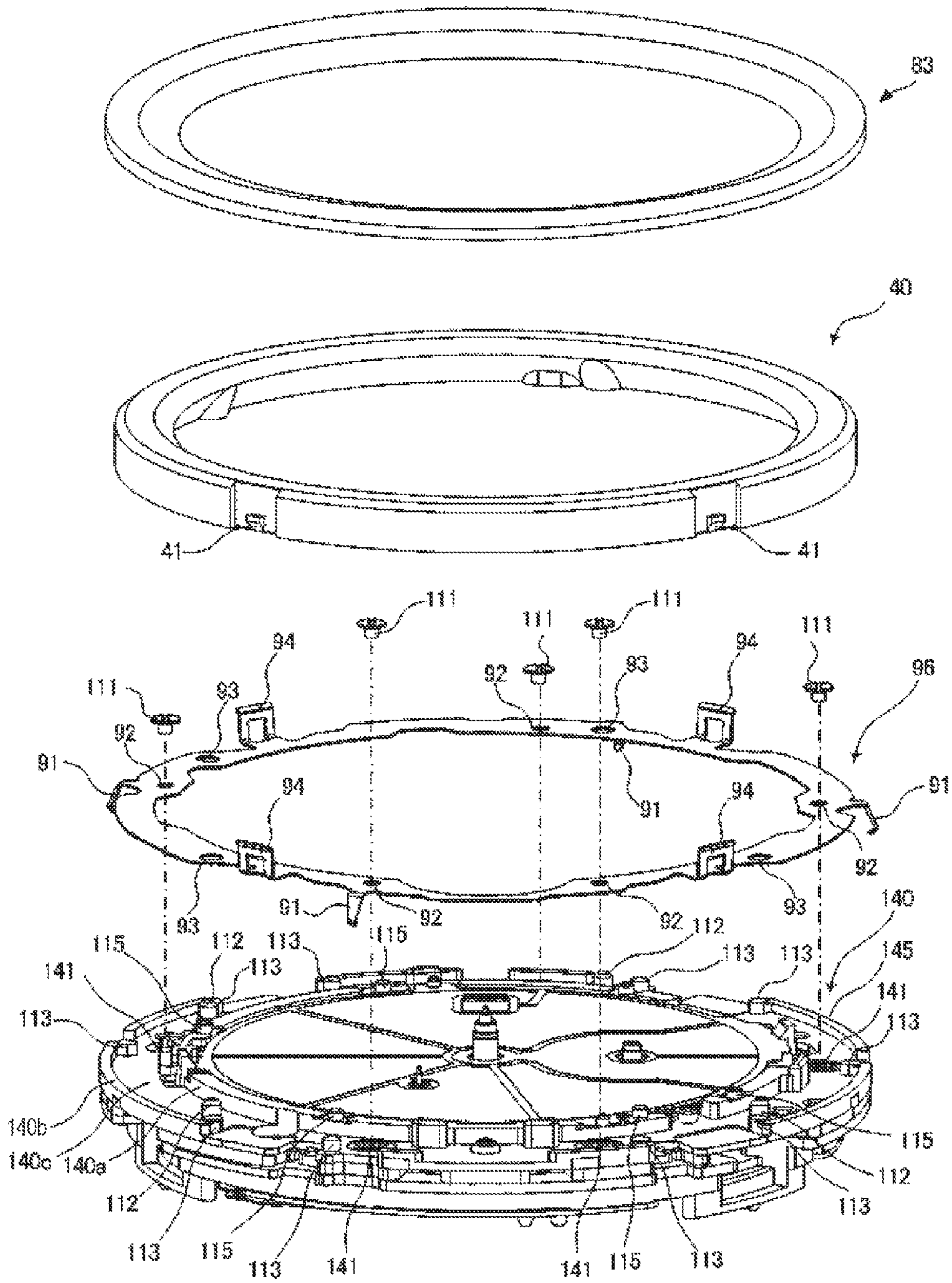
S2
27
28
M
S3
S1
K2
96

FIG. 9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92
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113
115
115
112
113
113
113
145
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140b
140c
140a
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115
113

FIG.10

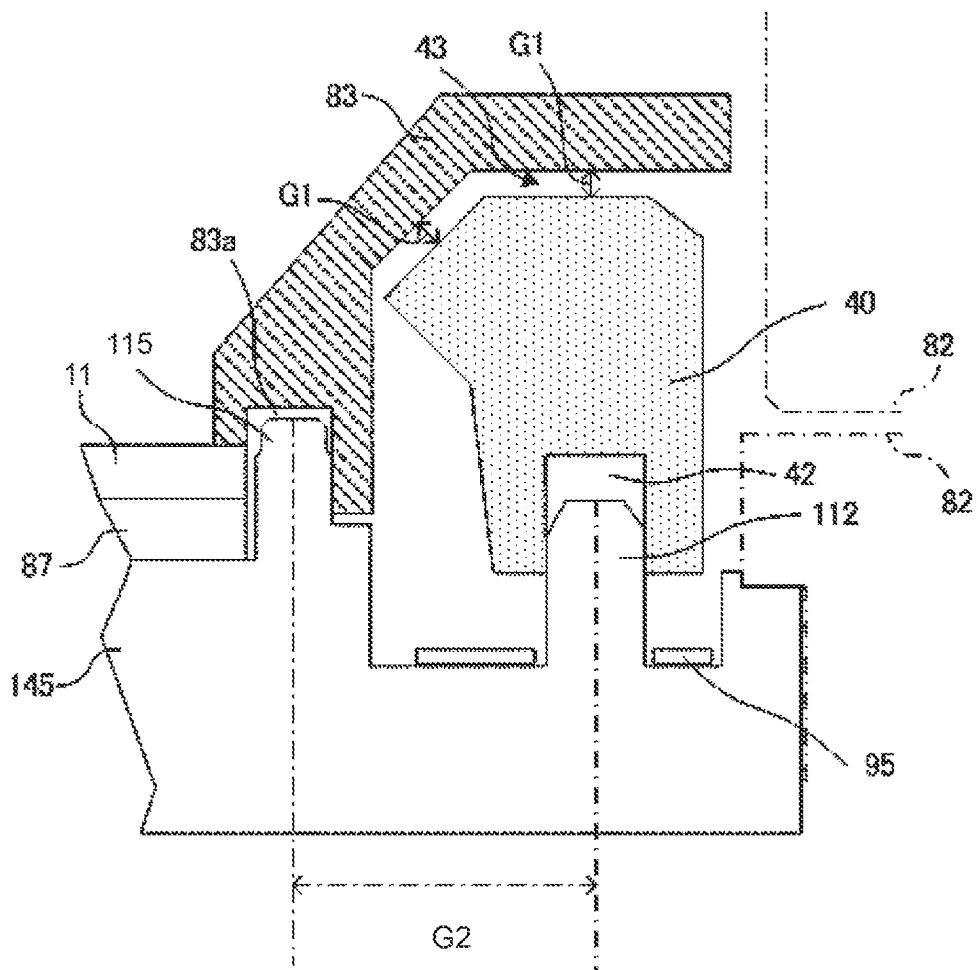


FIG.11

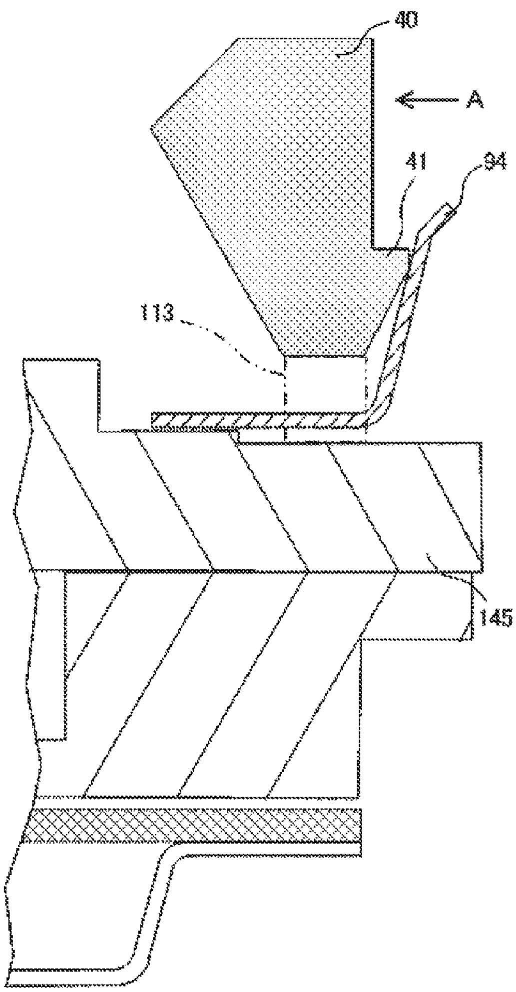


FIG.12A

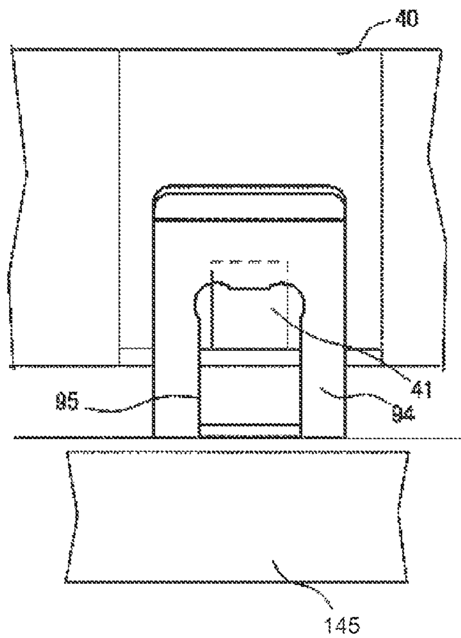


FIG.12B

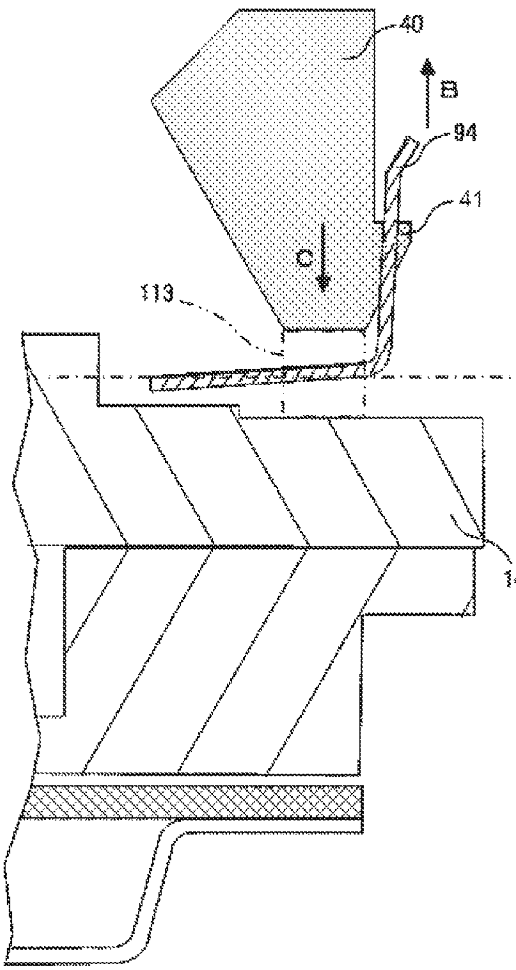


FIG.13A

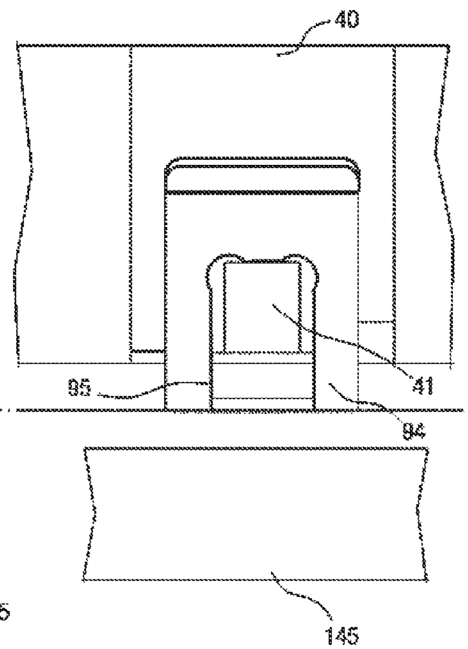


FIG.13B

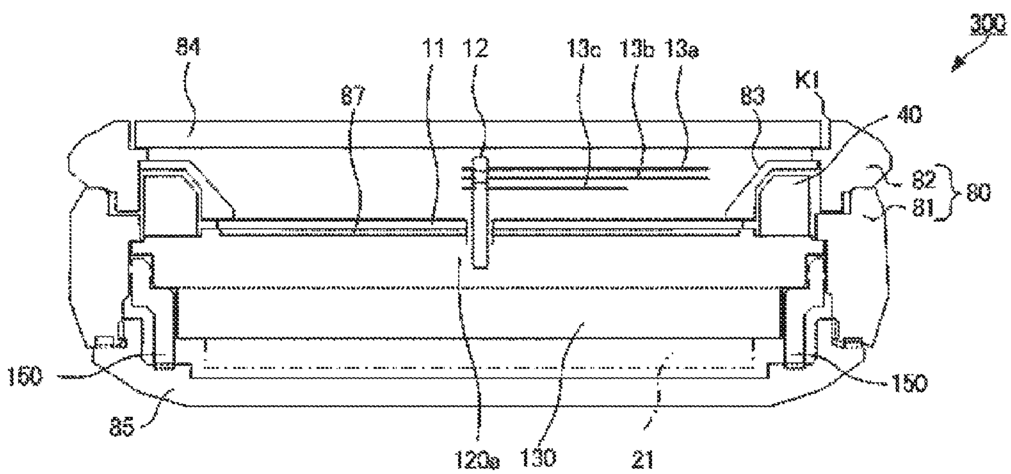
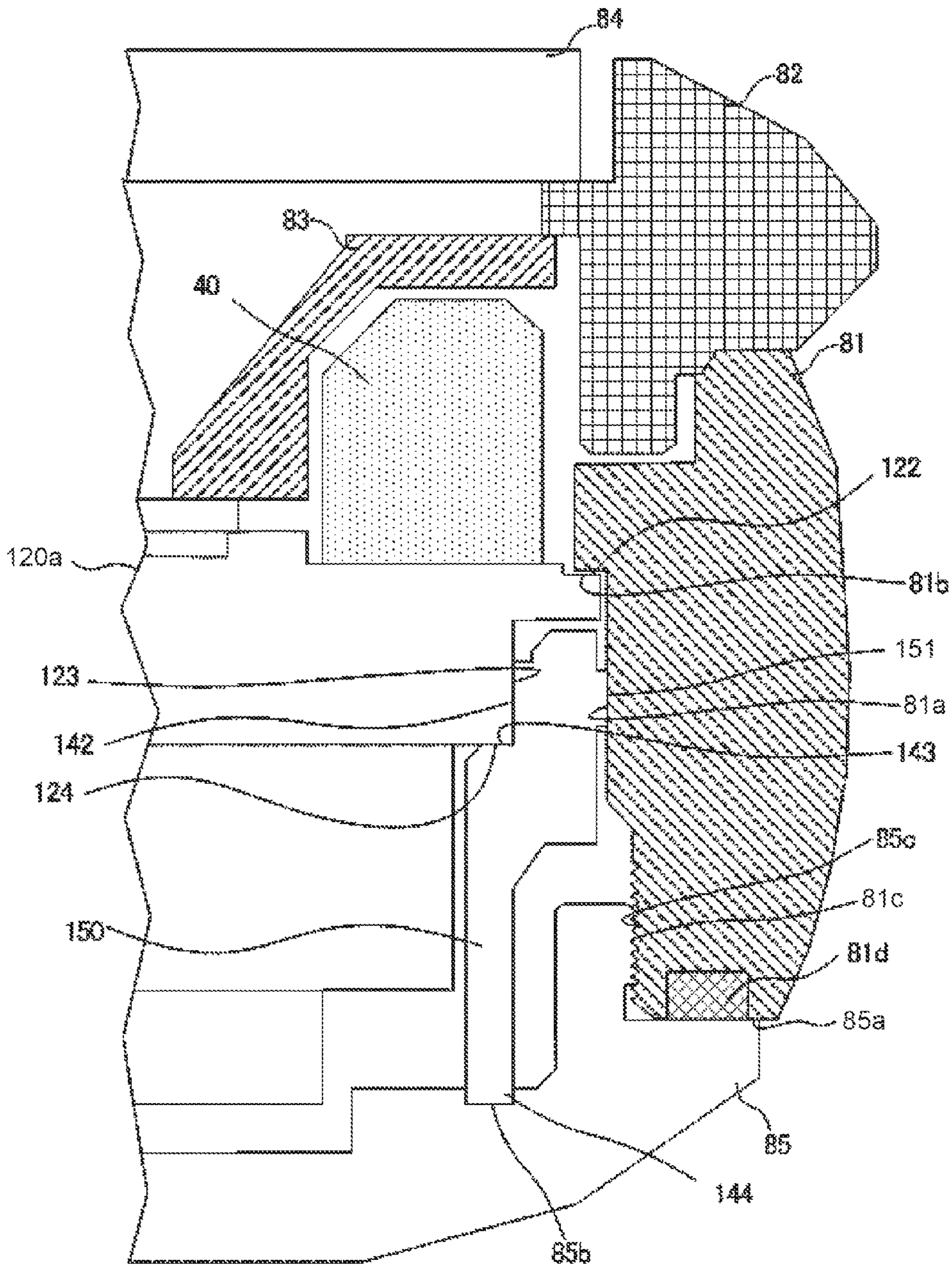


FIG.14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142
143
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85c
81c
150
81d
85a
85
144
85b

FIG.15

ELECTRONIC TIMEPIECE WITH INTERNAL ANTENNA

BACKGROUND

1. Technical Field

The present invention relates to an electronic timepiece with an internal antenna.

2. Related Art

Electronic timepieces that receive signals from positioning information satellites such as GPS (Global Positioning System) satellites to display time accurately are known from the literature. Such electronic timepieces commonly have a ring-shaped antenna for receiving radio signals from the positioning information satellites. See, for example, Japanese Unexamined Patent Appl. Pub. JP-A-2011-21929.

In this type of electronic timepiece, the ring-shaped antenna is disposed inside the outside case around the time display part (such as the dial) of the electronic timepiece. The antenna is also commonly covered from above by a dial ring for aesthetic purposes. The dial ring is also usually plastic or other non-conductive material in order to achieve better reception performance in the antenna.

The antenna can conceivably be held by the outside case in order to maintain a specific distance between the antenna and the case in timepieces according to the related art, but because suitable reception performance must be maintained in the antenna when driving an electronic timepiece with an internal antenna, the antenna is typically fixed in position relative to the movement during the manufacturing process.

However, if the outside case member located close to the antenna is metal, and the ring-shaped antenna is disposed close to the metal case, the resonance frequency characteristic of the antenna may vary. To maintain good signal reception performance in the antenna of an electronic timepiece with internal antenna, maintaining a specific distance between the antenna and the case, and keeping the effect of the case on reception performance constant, are therefore important.

Because even the plastic materials used for the dial ring have slight permittivity, the resonance frequency of the antenna disposed near the dial ring fluctuates and affects the signal reception performance of the antenna. To maintain good signal reception performance in the antenna of an electronic timepiece with internal antenna, maintaining a specific distance between the antenna and the dial ring, and keeping the effect of the dial ring on reception performance constant, are therefore important.

SUMMARY

The present invention is directed to the foregoing problem by maintaining a constant distance between the antenna and outside case, and assuring good antenna reception performance in an electronic timepiece with internal antenna having an antenna that is positioned and fixed to the movement. The invention also maintains a constant relative position between the antenna and dial ring, and assures good antenna reception performance in an electronic timepiece with internal antenna.

One aspect of the invention is an electronic timepiece with internal antenna, including: a tubular outside case; a time display unit that displays time inside the case; a back cover that closes a case opening on the opposite side as the display side of the time display unit; a movement including a drive mechanism that drives the time display unit and a main plate that supports the drive mechanism; a vertical

positioning surface that projects in the radial direction of the case on the inside of the case; and an annular antenna that is held inside the case and is positioned relative to the movement; the main plate having an upward pressure part that engages the back cover and lifts the movement to the time display side, and a movement top positioning part that contacts the vertical positioning surface and positions the movement vertically to the case when the upward pressure part lifts the movement to the time display side.

In the electronic timepiece with internal antenna according to this aspect of the invention, the antenna is positioned relative to the movement. Because the main plate has an upward pressure part that lifts the movement to the time display side, and a movement top positioning part that positions the movement vertically to the case, reaction from the back cover works on the movement, the movement is positioned vertically to the outside case, and the antenna is positioned and fixed vertically relative to the case, as a result of fitting the outside case to the main plate of the movement on the back cover. As a result, the distance between the antenna and the outside case can be held constant, the effect of the case can be kept constant, and good antenna reception performance can be maintained.

In an electronic timepiece with internal antenna according to another aspect of the invention, a horizontal positioning surface is formed on the inside surface of the outside case; and a movement outside diameter engaging part that contacts the horizontal positioning surface and determines the horizontal position relative to the outside case is formed on the main plate.

By positioning and fixing the movement horizontally relative to the outside case, the antenna is also positioned and fixed horizontally to the case. As a result, the distance between the antenna and the outside case can be held constant, the effect of the case can be kept constant, and good antenna reception performance can be maintained.

Note that "tubular" as used herein includes rotational bodies represented by tubes.

"Annular" as used herein includes circles and rectangles, as well as open (such as C-shaped) rings that are open in part, and closed (such as O-shaped) rings that are completely closed.

The time display unit includes a timepiece dial, and the time display on this dial includes both analog displays with hands, and LCD or other digital displays. Examples of such hands include an hour hand, minute hand, and second hand.

"Horizontal" as used herein means within a plane parallel to the display surface of the time display unit, or the two-dimensional direction in a plane parallel to the radial direction of the cylindrical outside case. "Vertical" means the normal direction (display direction) perpendicular to the display surface of the time display unit, or the two-dimensional direction in the plane parallel to the direction perpendicular to the radial direction of the tubular outside case.

In an electronic timepiece according to another aspect of the invention, the main plate includes a first member made of a hard material disposed on the face side of the time display unit, and a second member made of a softer material than the first member and disposed on the back cover side. The movement outside engaging part and movement top positioning part are disposed to the first member, and the upward pressure part is disposed to the second member.

Because the upward pressure part is made of a soft material, the upward pressure part deforms slightly due to its pliability and elasticity when extreme pressure is applied from the back cover, and thus absorbs the pressure and is not damaged. By receiving and transferring reaction from the back cover to the above first member, the movement top positioning part is pushed against the vertical positioning surface of the case, and the main plate is positioned and fixed vertically to the case. The movement is also pressed and positioned relative to the case side because the outside diameter engaging part and the top positioning part of the movement are made of a hard material.

The upward pressure part can be formed by a member separate from the main plate. In this embodiment, the upward pressure part can be made from a different material than the main plate, pliability to reaction from the back cover and the strength required to secure the movement can be separately set, and the ease and freedom of design can be improved.

In an electronic timepiece with internal antenna according to another aspect of the invention, the upward pressure part is disposed between the main plate and the outside case, and includes a spacer outside diameter engaging part that contacts the horizontal positioning surface formed on the inside of the outside case, a spacer inside diameter positioning surface that contacts a movement outside diameter engaging part disposed to the outside surface of the main plate, a spacer lifter that engages the back cover and lifts the movement to the time display side, and a movement lifter that contacts a shoulder formed on the outside surface of the main plate.

By using the upward pressure part, this aspect of the invention can position and secure the main plate horizontally and vertically to the outside case even when the upward pressure part and the main plate are discrete members. More specifically, because the upward pressure part has a spacer outside diameter engaging part and a spacer inside diameter positioning surface, the movement outside diameter engaging part contacts the spacer inside diameter positioning surface, the spacer outside diameter engaging part contacts the horizontal positioning surface, and the spacer outside diameter engaging part is pushed to the outside when the upward pressure part is installed between the main plate and the case. As a result, the movement is positioned and secured horizontally relatively to the outside case.

Furthermore, because the upward pressure part includes a spacer lifter and a movement lifter, reaction from the back cover works on the upward pressure part and the spacer lifter is pushed in by fitting the case to the main plate of the movement disposed to the back cover. The pressure of fitting the case to the main plate of the movement also acts on the movement lifter that contacts a shoulder formed on the outside edge of the main plate, and the movement lifter pushes the main plate up. As a result, the movement top positioning part disposed to the main plate is pressed to the vertical positioning surface of the case, and the movement is positioned and secured vertically relative to the case.

In an electronic timepiece with internal antenna according to another aspect of the invention, the antenna receives signals from a positioning information satellite; and the movement is driven to display time based on the received signals.

This aspect of the invention enables accurately displaying the time.

Because the movement is thus positioned and fixed horizontally and vertically relative to the outside case, the antenna is also positioned and fixed horizontally and vertically relative to the case. As a result, the distance between the antenna and the outside case can be held constant, the effect of the case can be kept constant, and good antenna reception performance can be maintained.

Another aspect of the invention is an electronic timepiece with internal antenna, including: a tubular outside case; a movement housed inside the outside case and including a drive mechanism that drives a time display unit and a main plate that supports the drive mechanism; an annular antenna that is held inside the outside case; an annular top member disposed above the antenna; an antenna engaging part that positions the antenna relative to the movement; and a top member engaging part that positions the top member relative to the movement; the antenna engaging part and the top member engaging part being formed with the main plate.

In the electronic timepiece with internal antenna according to this aspect of the invention, the antenna engaging part and the top member engaging part are formed in unison with the main plate of the movement. The antenna and top member are respectively engaged by the antenna engaging part and the top member engaging part. Therefore, because the antenna and top member are engaged by the antenna engaging part and the top member engaging part formed in unison with the main plate, the relative positions of the antenna and top member can be kept constant, the effect of the top member on the antenna can be kept constant, and good antenna reception performance can be maintained.

The top member as used here includes members disposed above (on the crystal side of) the antenna, including the annular dial ring conforming to the shape of the antenna, and the dial.

Preferably, the antenna engaging part positions and prevents the antenna from moving horizontally and circumferentially relative to the main plate; and the top member engaging part positions and prevents the top member from moving horizontally and circumferentially relative to the main plate.

"Horizontal" as used herein means within a plane parallel to the display surface of the time display unit, or the two-dimensional direction in a plane parallel to the radial direction of the cylindrical outside case. "Vertical" means the normal direction (display direction) perpendicular to the display surface of the time display unit, or the two-dimensional direction in the plane parallel to the direction perpendicular to the radial direction of the tubular outside case.

Further preferably, the antenna engaging part has an antenna protrusion formed protruding vertically from the main plate; and the antenna has an antenna cavity that engages the antenna protrusion.

In another aspect of the invention, the top member engaging part has a top member protrusion formed protruding vertically from the main plate; and the top member has a top member cavity that engages the top member protrusion.

These aspects of the invention can easily position the antenna and top member horizontally and circumferentially relative to the movement.

Other objects and attainments together with a fuller understanding of the invention will become apparent and appreciated by referring to the following description and claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overview of a GPS system including an electronic timepiece **100** with an internal antenna according to a first embodiment of the invention.

FIG. **2** is a plan view of the electronic timepiece **100**.

FIG. **3A** is a side view of the electronic timepiece **100**.

FIG. **3B** is a partial section view of the electronic timepiece **100**.

FIG. **4** is an exploded view of part of the electronic timepiece **100**.

FIG. **5** is a block diagram showing the circuit configuration of the electronic timepiece **100**.

FIG. **6** is a partial section view showing the structure that fixes the movement to the outside case of the electronic timepiece **100**.

FIG. **7**A is a top view showing where pressure is applied between the horizontal positioning surface **81***a* and the movement engaging parts **121** on the outside circumference of the movement in the electronic timepiece **100**.

FIG. **7**B is an enlarged view of part of FIG. **7**A.

FIG. **8**A is a side view showing the upward pressure part **131** of the electronic timepiece **100**.

FIG. **8**B is a section view through A-A in FIG. **8**A.

FIG. **9** is a partial section view of the electronic timepiece **200** with internal antenna according to a second embodiment of the invention.

FIG. **10** is an exploded view of part of the electronic timepiece **200**.

FIG. **11** is a partial section view showing engagement of the antenna element and dial ring of the electronic timepiece **200** with protrusions formed on the main plate of the movement.

FIG. **12**A and FIG. **12**B are partial section views showing the vertical positioning part of the antenna element of the electronic timepiece **200**.

FIG. **13**A and FIG. **13**B are partial section views showing the vertical positioning part of the antenna element of the electronic timepiece **200**.

FIG. **14** is a side view of an electronic timepiece **300** according to another embodiment of the invention.

FIG. **15** is a partial section view showing the structure that fixes the movement to the outside case of the electronic timepiece **300**.

DESCRIPTION OF EMBODIMENTS

Preferred embodiments of the present invention are described below with reference to the accompanying figures. Note that the size and scale of parts shown in the figures differ from the actual size and scale for convenience. Furthermore, the following examples are specific preferred embodiments of the invention and describe technically desirable limitations, and the scope of the invention is not limited thereby unless such limitation is specifically stated below.

Embodiment 1

A first embodiment of the invention is described below with reference to FIG. **1** to FIG. **8**.

A. Mechanical Configuration of an Electronic Timepiece with Internal Antenna

FIG. **1** shows the basic concept of a GPS system that includes an electronic timepiece **100** with an internal antenna according to a preferred embodiment of the invention.

The electronic timepiece **100** is a wristwatch that receives signals (radio signals) from at least one of plural GPS satellites **20** and adjusts the time based thereon, and displays the time on the surface (side) (referred to below as the "face") on the opposite side as the surface (referred to below as the "back") that contacts the wrist.

A GPS satellite **20** is an example of a positioning information satellite that orbits the Earth on a specific orbit, and transmits a navigation message superimposed on a 1.57542 GHz RF signal (L1 signal). The 1.57542 GHz signal carrying a superimposed navigation message is referred to herein as simply a "satellite signal." These satellite signals are right-handed circularly polarized waves.

The invention is described below using the GPS system as an example of a satellite positioning system, but the invention is not so limited. More particularly, the invention can be used with Global Navigation Satellite Systems (GNSS) such as Galileo (EU), GLONASS (Russia), and Beidou (China), and other positioning information satellites that transmit satellite signals containing time information, including the SBAS and other geostationary or quasi-zenith satellites.

The electronic timepiece **100** may therefore be a wristwatch that receives radio waves (radio signals) from positioning information satellites other than GPS satellites **20**, and adjusts the internal time based thereon.

There are currently approximately 31 GPS satellites **20** in the constellation. Only 4 of the 31 satellites are shown in FIG. **1**.

Each GPS satellite **20** superimposes a unique pattern called a C/A code (Coarse/Acquisition Code), which is a 1023-chip (1 ms) pseudorandom noise code unique to a specific GPS satellite **20**, on the satellite signal. This code is used to identify which GPS satellite **20** transmitted a particular satellite signal. Each chip is a value of +1 or −1, and the C/A code appears to be a random pattern. The C/A code superimposed on the satellite signal can therefore be detected by correlating the satellite signal that is actually received with the known pattern of each C/A code.

Each GPS satellite **20** carries an atomic clock, and the highly precise time information ("GPS time information" below) kept by the atomic clock is included in the satellite signal transmitted by the GPS satellite **20**. The time difference of the atomic clock onboard each GPS satellite **20** is measured by the ground control segment, and a time correction parameter for correcting this time difference is also included in the satellite signal. The electronic timepiece **100** receives a satellite signal transmitted from one GPS satellite **20**, and adjusts the internal time to the correct time using the GPS time information and time correction parameter contained in the received signal.

Orbit information indicating the position of the GPS satellite **20** on its orbit is contained in the satellite signal. The electronic timepiece **100** can calculate its own position using the GPS time information and orbit information. This position calculation assumes that there is some degree of error in the internal time kept by the electronic timepiece **100**. More specifically, in addition to the three parameters for determining the three-dimensional position of the electronic timepiece **100**, this time error is also an unknown. The electronic timepiece **100** therefore generally receives satellite signals from four or more GPS satellites, and calculates its own position using the GPS time information and orbit information contained in each of the received signals.

FIG. **2** is a plan view of the electronic timepiece **100**.

As shown in FIG. **2**, the electronic timepiece **100** has an outside case **80**. The case **80** includes a cylindrical body **81** made of metal or other conductive material, and a bezel **82** made of a non-conductive material such as ceramic. The bezel **82** is pressed into the body **81**.

An annular dial ring **83** made of a non-conductive material such as plastic is disposed inside the bezel **82**, and a round dial **11** is disposed inside the dial ring **83**.

Numbers denoting the offset from UTC are disposed at appropriate intervals around the dial ring **83**, and bar-shaped hour markers are disposed every 30 degrees around the dial **11**, in this embodiment. The information shown on the dial ring **83** and the information shown on the dial **11** are different from each other, and are not limited to the information shown in the figure.

Hands **13** (**13***a* to **13***c*) that turn on a center pivot **12** and indicate the current time are disposed above the dial **11**. The dial **11** may also be referred to as the time display unit below.

Further described below, the case **80** has two openings, one each on the face and the back cover sides.

The opening on the face side of the case **80** is covered by a crystal **84** through an intervening bezel **82**, and the dial **11** and hands **13** (**13***a* to **13***c*) are visible through the crystal **84**.

As also shown in FIG. **1** and FIG. **2**, the electronic timepiece **100** has a crown **16** and pushers **17**, **18**. The crown **16** and pushers **17**, **18** can be manually operated to set the electronic timepiece **100** to at least a mode (time information acquisition mode) that receives satellite signals from at least one GPS satellite **20** and adjusts the internal time, and a mode (positioning information acquisition mode) that receives signals from plural GPS satellites **20**, calculates the current position, and adjusts the time difference of the internal time. The electronic timepiece **100** can also execute the time information acquisition mode and positioning information acquisition mode regularly (automatically).

FIG. **3**A is a side view showing the internal structure of the electronic timepiece **100**, FIG. **3**B is a section view showing part of the internal structure of the electronic timepiece **100**, and FIG. **4** is an exploded oblique view showing parts of the electronic timepiece **100**.

As shown in FIG. **3**A, the electronic timepiece **100** has an outside case **80**, a back cover **85** that covers the case opening on the opposite side as the face side of the time display unit, and a movement **110** having a drive mechanism **30** that drives the time display unit, for example.

The case **80** includes a cylindrical body **81** made of metal or other conductive material and a bezel **82** made of a non-conductive material such as ceramic, and the bezel **82** is pressed into the body **81**. The case **80** has a top opening **K1** and a bottom opening **K2**. The top opening **K1** of the case **80** is covered by the round crystal **84**, and the bottom opening **K2** is covered by a back cover **85** made of SUS (stainless steel), Ti (titanium), or other conductive material. The body **81** and back cover **85** screw together, for example.

The ring-shaped dial ring **83** made of plastic or other non-conductive material is disposed to the inside circumference of the bezel **82** below (on the back cover side of) the crystal **84**. The movement **110** is disposed inside the inside circumference of the body **81** below the dial ring **83**.

The movement **110** includes the drive mechanism **30** and a main plate **120** that holds the drive mechanism **30**. As shown in FIG. **3**A, the movement **110** is fit to the inside of the case **80** and has hands **13** disposed on the time display unit (face) side. The main plate **120** of the movement **110** is a member made from a hard material (first member) that is non-conductive and has a constant strength.

A "hard" material as used here means a material with little deformation to compression and tension, and includes plastics such as PPS (polyphenylene sulfide), PTES (polythioethersulfone), PC (polycarbonate), LCP (liquid crystal polymer), and PA (polyamide).

A circuit bridge **130** is disposed below the movement **110**. The circuit bridge **130** is a member that receives and transfers reaction from the back cover **85** to the movement **110** above, and holds a circuit block **21** including the circuit board **25**. This circuit bridge **130** is a non-conductive material, and is made from a material (second member) that is softer than the main plate **120** of the movement **110**.

A "soft" material as used here means a material that is pliable to compression and tension, deforms slightly due to its pliability and elasticity, and is durable. Examples of such materials include POM (polyacetal) and PAR (polyarylate).

A donut-shaped storage space is formed by the movement **110**, circuit bridge **130**, dial ring **83**, and inside surface of the case **80**. The annular antenna **40** is housed in this space. The antenna **40** is therefore disposed on the inside side of the inside circumference of the bezel **82**, and the top of the antenna **40** is covered by the dial ring **83**.

An annular ground plane **90** made of metal is disposed in this space between the antenna **40** and the movement **110**. The ground plane **90** is electrically connected to the body **81** through a spring (not shown in the figure) disposed to the ground plane **90**, and because the back cover **85** is fixed to the body **81**, the ground plane **90** is also electrically connected to the back cover **85**.

More specifically, the ground plane **90** is electrically connected to the ground of the circuit board **25** through the path: ground plane **90**->spring disposed to the ground plane **90**->body **81**->back cover **85**->conductive spring **24**->circuit board **25** ground. The antenna **40** is fit together with protrusions (not shown in the figure) formed on the top surface of the main plate **120** of the movement **110**, thereby positioned horizontally and circumferentially to the movement **110**, and prevented from rotating and shifting horizontally.

The antenna **40** has an antenna element made of metal or other conductive material formed by a plating or silver paste printing process, for example, on an annular base made of a dielectric material. The antenna **40** in this embodiment is disposed around the dial **11**, housed on the inside circumference side of the bezel **82**, and covered from above by the dial ring **83** and crystal **84**.

The dielectric base of the antenna **40** is adjusted to a constant Σr of approximately 5-20 by mixing a dielectric material that is used in high frequency applications, such as titanium oxide, with resin. The wavelength shortening effect of the dielectric can thus be used to reduce the size of the antenna.

For example, the frequency of signals from GPS satellites **20** is 1.575 GHz, the length of one wave is approximately 19 cm, embedding a normal antenna of this size in the bezel of a wristwatch is not possible, and wavelength shortening is required. A dielectric with a constant Σr of 5-20 is therefore used in this embodiment to achieve a wavelength shortening rate of $(\cdot r)^{-1/2}$ in the dielectric base. The size of the antenna can therefore be reduced, and a 1-wavelength loop antenna can be fit in a wristwatch as an antenna for receiving GPS signals.

The antenna **40** is fed through a feed node, and a feed pin **44** disposed below the antenna is connected to this feed node. The feed pin **44** is a pin-shaped connector made of metal, is disposed to the top of the circuit board **25**, passes through a through-hole formed in the main plate **120** of the movement **110** and enters the storage space, and connects the circuit board **25** with the antenna **40** inside this storage space.

Good reception performance can also be assured because the antenna **40** is located below the crystal **84**. The freedom of design is also not impaired because the top of the antenna **40** is covered by the dial ring **83**, the antenna **40** is therefore not exposed, and the top of the dial ring **83** can be designed as desired. The freedom of design of the dial **11** is also not impaired because the antenna **40** is located outside the dial **11**.

As shown in FIG. **3**B, an optically transparent dial **11**, a solar panel **87** for solar power generation, a center pivot **12** passing through the dial **11**, solar panel **87**, and main plate **120** of the movement **110**, and plural hands **13** (second hand **13***a*, minute hand **13***b*, hour hand **13***c*) that move around the center pivot **12** and display the current time, are disposed inside the inside circumference of the antenna **40**.

The solar panel **87** is a round disc having plural solar cells (photovoltaic devices) that convert light energy to electrical energy (power) connected in series. The solar panel **87** is disposed inside the inside circumference of the antenna **40** and between the movement **110** and dial **11**. A center hole through which the center pivot **12** passes is formed in the center of the solar panel **87**.

The center pivot **12** extends in the direction between the face and back along the center axis of the case **80**. The dial **11** is round and made of plastic or other optically transparent non-conductive material. As shown in FIG. **3**A, the dial **11** is disposed between the crystal **84** and movement **110**. A hole through which the center pivot **12** passes is formed in the center of the dial **11**. The hands **13** are disposed between the crystal **84** and the dial **11** inside the inside circumference of the antenna **40**.

A drive mechanism (drive unit) **30** that causes the center pivot **12** to turn and drives the plural hands **13** is disposed below (on the back cover side of) the main plate **120** of the movement **110** as shown in FIG. **3**B. The drive mechanism **30** includes a stepper motor M and wheel train, and drives the hands **13** by the stepper motor M causing the center pivot **12** to turn through the wheel train. More specifically, the drive mechanism **30** causes the center pivot **12** to turn so that the hour hand **13***c* turns one revolution in 12 hours, the minute hand **13***b* turns one revolution in 60 minutes, and the secondhand **13***a* turns one revolution in 60 seconds.

The electronic timepiece **100** has a circuit board **25** inside the case **80**. The circuit board **25** is made of resin or other material including a dielectric, and is disposed below the drive mechanism **30** (that is, between the drive mechanism **30** and the back cover **85**).

A circuit block **21** including a GPS reception unit (radio receiver) **26** and control unit **70** is disposed on the bottom (on the surface facing the back of the wristwatch) of the circuit board **25**. The GPS reception unit **26** is a single-chip IC module, for example, and includes analog and digital circuits. The control unit **70** sends control signals to the GPS reception unit **26** and controls the reception operation of the GPS reception unit **26**, and controls operation of the drive mechanism **30**.

A feed pin **44** made of metal or other conductive material is disposed to the top of the circuit board **25**. The feed pin **44** has an internal spring, passes through the ground plane **90** and contacts the antenna **40**, and passes through the main plate **120** of the movement **110** and contacts the circuit board **25**. The feed means of the antenna **40** is therefore electrically connected to the circuit board **25** (more precisely, to wiring disposed to the circuit board **25**) through the feed pin **44**, and received signals are supplied from the antenna **40** to the circuit board **25**.

The circuit block **21** including the GPS reception unit **26** and control unit **70** is covered by a member made of a conductive material with a shield effect, and is electrically connected to the ground plane **90** through a circuit support **39**, the back cover **85**, and the body **81**. Ground potential is supplied through a conductive spring **24** to the circuit block **21**. More specifically, the circuit support **39**, back cover **85**, body **81**, and ground plane **90** are held at the ground potential of the circuit block, and function as a ground plane.

The magnetic screens S1 and S2 are disposed between the drive mechanism **30** and the main plate **120**, and another magnetic screen S3 is disposed between the drive mechanism **30** and circuit board **25**. Magnetic screens S1 and S2 are referred to below as a first magnetic screen, and magnetic screen S3 as a second magnetic screen. Magnetic screens S1 to S3 are made of a conductive material with high permeability, such as pure iron.

If there is a speaker or other object that produces a strong magnetic field on the outside of the electronic timepiece **100**, the magnetic field can cause the stepper motors M to operate incorrectly. Of the parts of the electronic timepiece **100**, metal in the body **81** and back cover **85** produces a magnetic field when magnetized. Circuit blocks **21** on the circuit board **25** can also produce a magnetic field.

By covering the stepper motors M with magnetic screens S1 to S3 made of a high permeability material, this embodiment of the invention magnetically shields the drive mechanism **30** and prevents the stepper motor M from operating incorrectly due to the magnetic fields described above.

A lithium ion battery or other cylindrically shaped storage battery **27**, and a battery compartment **28** for holding the storage battery **27**, are also disposed inside the case **80** of the electronic timepiece **100**.

The storage battery **27** is charged by the power produced by the solar panel **87**. The battery compartment **28** for holding the storage battery **27** is below the circuit board **25** (that is, between the circuit board **25** and back cover **85**).

The crown **16** and pushers **17**, **18** (FIG. **2**) are disposed on the outside of the case **80**. Movement of the crown **16** resulting from the user of the electronic timepiece **100** operating the crown **16** is transferred through the stem **16***a* passing through the case **80** to the drive mechanism **30**. Movement of the pusher **17** (or **18**) produced by the user of the electronic timepiece **100** pressing the pusher **17** (or **18**) is transferred to a switch not shown through the corresponding button stem passing through the case **80**. These switches convert pressure from the pusher **17** (or pusher **18**) to an electrical signal, and output the signal to the control unit **70**.

B. Circuit Configuration of the Electronic Timepiece with Internal Antenna

FIG. **5** is a block diagram showing the circuit configuration of the electronic timepiece **100**.

As shown in FIG. **5**, the electronic timepiece **100** includes a GPS reception unit **26** and a control display unit **36**. The GPS reception unit **26** executes processes related to receiving satellite signals, locking onto GPS satellites **20**, generating positioning information, and generating time correction information, for example. The control display unit **36** executes processes including keeping the internal time and adjusting the internal time.

A solar panel **87** charges the storage battery **27** through the charging control circuit **29**.

The electronic timepiece **100** has regulators **34** and **35**, and the storage battery **27** supplies drive power through a regulator **34** to the control display unit **36**, and supplies drive power through another regulator **35** to the GPS reception unit **26**.

The electronic timepiece **100** also has a voltage detection circuit **37** that detects the voltage of the storage battery **27**.

Regulator **35** could be split into a regulator **35-1** (not shown) that supplies drive power to the RF unit **50** (described below), and a regulator **35-2** (not shown) that supplies drive power to a baseband unit **60** (described below). In this implementation, regulator **35-1** could be disposed in the RF unit **50**.

The electronic timepiece **100** also has the antenna **40** described above and a SAW (surface acoustic wave) filter **32**. As described with reference to FIG. **1**, the antenna **40** receives satellite signals from plural GPS satellites **20**. However, because the antenna **40** also receives noise in addition to the satellite signals, the SAW filter **32** extracts the satellite signals from the signals received by the antenna **40**. In other words, the SAW filter **32** functions as a bandpass filter that passes signals in the 1.5 GHz waveband.

The GPS reception unit **26** includes the RF (radio frequency) unit **50** and baseband unit **60**. As described below, the GPS reception unit **26** executes a process that extracts satellite information including GPS time information and orbit information contained in the navigation message from the 1.5 GHz satellite signal extracted by the SAW filter **32**.

The RF unit **50** includes a LNA (low noise amplifier) **51**, mixer **52**, VCO (voltage controlled oscillator) **53**, PLL (phase-locked loop) circuit **54**, IF (intermediate frequency) amplifier **55**, IF filter **56**, and A/D converter **57**.

The satellite signal passed by the SAW filter **32** is amplified by the LNA **51**. The satellite signal amplified by the LNA **51** is mixed by the mixer **52** with the clock signal output by the VCO **53**, and down-converted to a signal in the intermediate frequency band. The PLL circuit **54** phase compares a clock signal obtained by frequency dividing the output clock signal of the VCO **53** with a reference clock signal, and synchronizes the output clock signal of the VCO **53** to the reference clock signal. As a result, the VCO **53** can output a stable clock signal with the frequency precision of the reference clock signal. Note that several megahertz, for example, can be selected as the intermediate frequency.

The signal from the mixer **52** is amplified by the IF amplifier **55**. However, mixing by the mixer **52** also produces a high frequency component of several GHz in addition to the IF signal. The IF amplifier **55** therefore amplifies both the IF signal and the high frequency component of several GHz. The IF filter **56** therefore passes the IF signal and removes the high frequency component of several GHz (more accurately, attenuates the signal to a specific level or less). The IF signal passed by the IF filter **56** is converted to a digital signal by the A/D converter **57**.

The baseband unit **60** includes, for example, a DSP (digital signal processor) **61**, CPU (central processing unit) **62**, SRAM (static random access memory) **63**, and RTC (real-time clock) **64**. A TCXO (temperature compensated crystal oscillator) **65** and flash memory **66** are also connected to the baseband unit **60**.

The temperature compensated crystal oscillator (TCXO) **65** generates a reference clock signal of a substantially constant frequency regardless of temperature. Time zone information, for example, is stored in flash memory **66**. The time zone information defines the time difference between the current location and UTC based on specific coordinates (such as latitude and longitude).

The baseband unit **60** executes a process that demodulates the baseband signal from the digital signal (IF signal) output from the A/D converter **57** of the RF unit **50** when set to the time information acquisition mode or the positioning information acquisition mode.

In addition, when the time information acquisition mode or the positioning information acquisition mode is set, the baseband unit **60** executes a process that generates a local code of the same pattern as each C/A code, and correlates the local codes to the C/A code contained in the baseband signal, in the satellite search step. The baseband unit **60** adjusts the timing when the local code is generated to find the peak correlation to each local code, and when the correlation equals or exceeds a threshold value, confirms synchronization with the GPS satellite **20** matching the local code (that is, confirms locking onto a GPS satellite **20**). Note that the GPS system uses a CDMA (Code Division Multiple Access) method whereby all GPS satellites **20** transmit satellite signals on the same frequency using different C/A codes. The GPS satellites **20** that can be locked onto can therefore be found by identifying the C/A code contained in the received satellite signal.

To acquire the satellite information from the satellite signal of the GPS satellite **20** that was locked onto in the time information acquisition mode or the positioning information acquisition mode, the baseband unit **60** executes a process that mixes the baseband signal with the local code of the same pattern as the C/A code of the GPS satellite **20** that was locked.

The navigation message containing the satellite information of the GPS satellite **20** that was locked onto is demodulated in the mixed signal. The baseband unit **60** then executes a process to detect the TLM word (preamble data) of each subframe in the navigation message, and acquire (such as store in SRAM **63**) satellite information such as the orbit information and GPS time information contained in each subframe. The GPS time information as used here is the week number (WN) and Z count, but the Z count data alone could be acquired if the week number was previously acquired. The baseband unit **60** then generates the time adjustment information required to correct the internal time based on the satellite information.

In the time information acquisition mode, the baseband unit **60** more specifically calculates the time based on the GPS time information, and generates time correction information. The time correction information in the time information acquisition mode may be the GPS time information, or information about the time difference between the GPS time and internal time.

However, in the positioning information acquisition mode, the baseband unit **60** more specifically calculates the position based on the GPS time information and orbit information, and acquires the location information (more specifically calculates the latitude and longitude of the electronic timepiece **100** when the satellite signals were received).

Next, the baseband unit **60** references the time difference (time zone) information stored in flash memory **66**, and acquires the time difference at the coordinates (such as latitude and longitude) of the electronic timepiece **100** determined from the positioning information. The baseband unit **60** thus generates satellite time data (GPS time information) and time zone (time difference) data as the time correction information. The time correction information used in the positioning information acquisition mode may thus be the GPS time information and time zone information as described above, but the time difference between the internal time and the GPS time could be used instead of the GPS time information.

Note that the baseband unit **60** can generate the time correction information using the GPS time information from one GPS satellite **20**, or the baseband unit **60** can generate the time correction information from satellite information from a plurality of GPS satellites **20**.

Operation of the baseband unit **60** is synchronized to the reference clock signal output by the TCXO **65**. The RTC **64** generates the timing for satellite signal processing, and counts up at the reference clock signal output from the TCXO **65**.

The control display unit **36** includes a control unit **70**, crystal oscillator **73**, and drive circuit **74**.

The control unit **70** includes a storage unit **71** and a RTC (real-time clock) **72**, and controls various operations. The control unit **70** can be rendered with a CPU, for example. The control unit **70** outputs control signals to the GPS reception unit **26**, and controls reception by the GPS reception unit **26**. The control unit **70** also controls operation of regulators **34**, **35** based on output from the voltage detection circuit **37**. The control unit **70** also controls movement of the hands **13** through the drive circuit **74**.

Received data is stored in the storage unit **71**. The control unit **70** adjusts the internal time based on the received data. The internal time is the time kept in the electronic timepiece **100** by the RTC **72**. The RTC **72** operates continuously, and counts up at the reference clock signal generated by the crystal oscillator **73**. The control unit **70** can therefore update the internal time and continue moving the hands even when power is not supplied to the GPS reception unit **26**.

When the time information acquisition mode is set, the control unit **70** controls operation of the GPS reception unit **26**, corrects the internal time based on the GPS time, and stores the time in the storage unit **71**. More specifically, the internal time is corrected to UTC (Coordinated Universal Time) by adding a UTC offset to the acquired GPS time.

When the positioning information acquisition mode is set, the control unit **70** controls operation of the GPS reception unit **26**, corrects the internal time based on the satellite time data (GPS time) and time zone (time difference) data, and stores the time in the storage unit **71**.

C. Fastening Structure of the Electronic Timepiece with Internal Antenna

The fastening structure of the electronic timepiece **100** according to this embodiment of the invention is described next. FIG. **6** is a section view of part of the movement and outside case fastening structure of the electronic timepiece **100**. FIG. **7**A is a top view showing contact between the movement engaging parts **121** and the horizontal positioning surface **81***a* of the electronic timepiece **100**, and FIG. **7**B is an enlarged view of part of FIG. **7**A. FIG. **8**A is a side view showing the upward pressure part **131** of the electronic timepiece **100**, and FIG. **8**B is a section view through line A-A in FIG. **8**A.

The structure for fastening the back cover **85** to the body **81** is described first. As shown in FIG. **6**, a horizontal engagement part **85***c*, which is a thread that is screwed to the body **81**, and a vertical engagement part **85***a* that contacts and vertically positions and fixes the back cover **85** to the body **81**, are formed around the outside circumference of the back cover **85**. A screw thread **81***c* that threads together with the horizontal engagement part **85***c*, and packing **81***d* that is vertically compressed to form a seal with the vertical engagement part **85***a*, are disposed to the body **81**.

This construction horizontally positions the back cover **85** to the body **81** by screwing the horizontal engagement part **85***c* and the screw thread **81***c* together. The back cover **85** is also vertically positioned to the body **81** by the vertical engagement part **85***a* sealing against the packing **81***d*.

The structure for horizontally fastening the movement **110** to the body **81** is described next. As shown in FIG. **6**, the body **81** has a horizontal positioning surface **81***a* formed on the inside surface of the body **81**. Plural movement engaging parts **121** are formed on the outside circumference surface of the main plate **120** of the movement **110**. As shown in FIG. **7**A and FIG. **7**B, these movement engaging parts **121** are pressed against the horizontal positioning surface **81***a* and horizontally position the main plate **120** to the body **81**.

When the movement **110** is placed inside the body **81**, the movement engaging parts **121** in this configuration are pressed by the horizontal positioning surface **81***a*, and the movement engaging parts **121** are pushed to the outside. As a result, the movement **110** is horizontally positioned to the body **81**.

The structure for vertically fastening the movement **110** to the body **81** is described next. As shown in FIG. **6**, a vertical positioning surface **81***b* that protrudes radially to the inside of the body **81** is disposed on the inside surface on the time display unit side of the body **81**. A movement top positioning part **122** that is pushed against the vertical positioning surface **81***b* and vertically positions the movement **110** to the body **81** is disposed to the main plate **120** of the movement **110**.

An upward pressure part **131** pushes the movement **110** to the face side of the timepiece in this embodiment of the invention. More specifically, the upward pressure part **131** is formed on the circuit bridge **130** on the bottom of the movement **110**, and protrudes toward the back cover **85** as shown in FIG. **6**. A pressure channel **85***b* that engages the upward pressure part **131** is disposed to the back cover **85** at a position opposite the upward pressure part **131**. As shown in FIG. **8**A and FIG. **8**B, the upward pressure part **131** has a protruding part **131***a* that protrudes down, and when the back cover **85** is screwed onto the body **81** with the movement **110** housed inside, the upward pressure part **131** fits into the pressure channel **85***b*.

D. Benefit of the Embodiment

This embodiment of the invention positions the antenna **40** horizontally to the movement **110**. By fitting the case **80** over the movement **110** on the back cover **85**, reaction from the back cover **85** is applied to the movement **110**, the movement **110** is vertically positioned and fixed to the case **80** by the movement top positioning part **122** of the movement **110** and the upward pressure part **131** of the circuit bridge **130**, the movement **110** is horizontally positioned to the case **80** by the movement engaging parts **121** of the movement **110**, and the antenna **40** is thus also horizontally and vertically positioned and fixed relative to the case **80**. As a result, the distance between the antenna **40** and case **80** can be held constant, the effect of the case **80** can be made constant, and good antenna reception performance can be maintained.

Because the upward pressure part **131** of the circuit bridge **130** disposed on the back cover **85** side is made of a softer material than the main plate **120** of the movement **110** in this embodiment, the upward pressure part **131** deforms slightly due to its pliability and elasticity, absorbs pressure, and is not damaged even when compressed and extreme pressure is applied from the back cover **85**. The movement top positioning part **122** also contacts the vertical positioning surface **81***b* of the case, and the movement **110** is vertically positioned to the body **81**, due to the reaction from the back cover **85** transmitted to the main plate **120** of the movement **110**.

Furthermore, because the main plate **120** of the movement **110** is made from a hard material, the drive mechanism **30** and other parts stored inside can be protected, and the movement can be pushed to the body **81** side and appropriately secured. This embodiment also does not require a separate member to secure the movement, the parts count is therefore reduced, and a larger space is not required to hold the movement.

Embodiment 2

A second embodiment of the invention is described below with reference to FIG. **9** to FIG. **13**. The first embodiment describes holding a constant distance between the antenna **40** and case **80**. This second embodiment describes holding the antenna **40** in a constant position relative to the dial ring **83**. Further detailed description of like parts in this and the first embodiment is omitted while the differences with the first embodiment are described below.

A. Mechanical Configuration of an Electronic Timepiece with Internal Antenna

FIG. **9** is a side view showing the internal structure of the electronic timepiece **200** according to this embodiment of the invention, and FIG. **10** is an exploded oblique view showing parts of the electronic timepiece **200**.

As shown in FIG. **9**, a ring-shaped dial ring **83** made of plastic or other non-conductive material is disposed to the inside circumference of the bezel **82** below (on the back cover side of) the crystal **84**. A movement **140** with a main plate **145** made of plastic or other non-conductive material is disposed inside the inside circumference of the body **81** below the dial ring **83**.

The movement **140** includes the drive mechanism **30** and the main plate **145** that holds the drive mechanism **30**. As shown in FIG. **9**, the movement **140** is fit to the inside of the case **80** and has hands **13** disposed on the time display unit (face) side. The main plate **145** of the movement **140** is a member made from a hard material (first member) that is non-conductive and has a constant strength.

A "hard" material as used here means a material with little deformation to compression and tension, and includes plastics such as PPS (polyphenylene sulfide), PTES (polythioethersulfone), PC (polycarbonate), LCP (liquid crystal polymer), and PA (polyamide).

A donut-shaped storage space is formed by the movement **140**, dial ring **83**, and inside surface of the case **80**. More specifically, the outside circumference side of the dial ring **83** is a flat ring-shaped part that contacts the inside surface of the bezel **82**, and the inside circumference side of the dial ring **83** is a bowl-shaped part that slopes to the inside. This donut-shaped storage space is formed by the ring-shaped part and the bowl-shaped parts of the dial ring **83**, and the inside circumference of the case **80**. The annular antenna **40** is housed in this space. In this embodiment, the dial ring **83** functions as the top member that covers the antenna **40**.

The antenna **40** is therefore disposed on the inside side of the inside circumference of the bezel **82**, and the top of the antenna **40** is covered by the dial ring **83**.

An annular ground plane **96** made of metal is disposed in this space between the antenna **40** and the movement **140**. The ground plane **96** is electrically connected to the back cover **85** through a conductive spring **24**, and because the back cover **85** is fixed to the body **81**, the ground plane **96** is also electrically connected to the body **81**.

The antenna **40** has an antenna element made of metal or other conductive material formed by a plating or silver paste printing process, for example, on an annular base made of a dielectric material. The antenna **40** in this embodiment is disposed around the dial **11**, housed on the inside circumference side of the bezel **82**, and covered from above by the dial ring **83** and crystal **84**.

A slope TP**1** that inclines at the same angle as the bowl-shaped part of the dial ring **83** is disposed to the antenna **40**. This slope TP**1** is formed contiguously to the top and sloping toward the dial **11** so that the height to the dial **11** decreases to the inside (toward the center pivot **12**).

As in the first embodiment, the dielectric base of the antenna **40** is adjusted to a constant ·r of approximately 5-20 by mixing a dielectric material that is used in high frequency applications, such as titanium oxide, with resin. The wavelength shortening effect of the dielectric can thus be used to reduce the size of the antenna. This feature is the same as in the first embodiment, and further detailed description thereof is thus omitted.

The antenna **40** is fed through a feed node, and a feed pin **44** disposed below the antenna is connected to this feed node. The feed pin **44** is a pin-shaped connector made of metal, is disposed to the top of the circuit board **25**, passes through a through-hole formed in the main plate **145** of the movement **140** and enters the storage space, and connects the circuit board **25** with the antenna **40** inside this storage space.

The circuit configuration of this electronic timepiece **200** is identical to the circuit configuration of the first embodiment shown in FIG. **5**, and further description thereof is omitted.

B. Attaching the Antenna and Dial Ring to an Electronic Timepiece with Internal Antenna

The method of attaching the antenna **40** and dial ring **83** in this embodiment is described next. As shown in FIG. **10**, the movement **140** in this embodiment has an antenna compartment **140***c* between an inside circumference wall **140***a* and an outside circumference wall **140***b*. A ring-shaped ground plane **96** made of metal is disposed as an urging member in this antenna compartment **140***c*, and the antenna **40** is secured in the movement **140** by engaging the ground plane **96** and the antenna **40**.

Antenna studs **112** are formed as antenna engagement parts protruding vertically from four locations on the main plate **145** of the movement **140**, and plural through-holes **93** through which these antenna studs **112** pass are formed in the ground plane **96**. By inserting these antenna studs **112** in these through-holes **93**, the ground plane **96** is positioned in the plane direction and circumferentially to the main plate **145** of the movement **140**.

As also shown in FIG. **10**, four conductive parts **91** are formed around the outside of the ground plane **96**, and these conductive parts **91** are configured to contact the inside of the case **80**.

Five screws **111** are then screwed into five screw holes **141** formed in the main plate **145** of the movement **140** through plural through-holes **92** formed in the ground plane **96**, firmly fastening the ground plane **96** to the main plate **145** of the movement **140**. The ground plane **96** in this embodiment is thus fixed in contact with the main plate **145** of the movement **140** at selected places by the plural screws **111** instead of the entire surface of the ground plane **96** being held in contact with the antenna compartment **140***c*.

Cavities that receive the antenna studs **112** described above are formed in the bottom of the antenna **40**, and the antenna **40** is positioned in the plane direction and circumferentially to the movement **140** by fitting the antenna studs

112 formed in the main plate **145** of the movement **140** in these cavities in the antenna **40**.

Dial ring studs **115** are formed at plural places on the main plate **145** as top member engaging parts that protrude vertically from the surface of the main plate **145** of the movement **140** on the inside circumference side of the antenna studs **112**. Dial ring cavities are formed in the bottom of the dial ring **83** as top member cavities that engage the dial ring studs **115** described above. The dial ring **83** is positioned in the plane direction and circumferentially to the movement **140** by fitting the dial ring studs **115** on the main plate **145** into the dial ring cavities in the dial ring **83**. Similar cavities can also be formed in the movement with matching protrusions formed on the antenna and dial ring.

The ground plane **96** also has four hooks **94**, and matching claw-like protrusions **41** are formed on the antenna **40** as catches that engage the hooks **94**. Plural pedestals **113** are also formed on the main plate **145** as reference surfaces for positioning the antenna **40** vertically.

Therefore, if the antenna **40** is installed so that the antenna studs **112** on the main plate **145** engage the cavities in the antenna **40** after the ground plane **96** is attached to the main plate **145**, the antenna **40** will contact the pedestals **113** at plural places. When the hooks **94** of the ground plane **96** are then engaged with the claw-like protrusions **41** formed on the antenna **40**, the antenna **40** is urged toward the main plate **145** by the elasticity of the ground plane **96**, and pushed against the pedestals **113**. The antenna **40** is thus reliably positioned vertically against the surface of the main plate **145**.

As shown in FIG. **10**, the positions where the hooks **94** and protrusions **41** engage, and the positions where the ground plane **90** is attached to the main plate **145** by the screws **111**, are set to specific intervals circumferentially around the main plate **145**. This enables imparting flexibility to the ground plane **96** so that when the antenna **40** is displaced by vibration, for example, the antenna **40** can be returned to its original position by the elasticity of the ground plane **96**. This is further described below.

C. Positioning the Antenna in the Electronic Timepiece with Internal Antenna

The configuration for positioning the antenna **40** in the electronic timepiece **200** according to this embodiment of the invention is described next.

As shown in FIG. **10**, the electronic timepiece **200** according to this embodiment of the invention has a movement **140**, a ring-shaped ground plane **96** made of metal, an antenna **40**, and a dial ring **83**. The ground plane **96** has conductive parts **91** that project below the ground plane **96** at four places around the circumference.

An antenna compartment **140***c* enclosed between an inside circumference wall **140***a* and outside circumference wall **140***b* is formed in the main plate **145** of the movement **140**. To attach the ground plane **96** to the main plate **145**, the antenna studs **112** formed to the main plate **145** are first passed through the through-holes **93** in the ground plane **96**, and the ground plane **96** is then placed in the antenna compartment **140***c*. By inserting the antenna studs **112** to the through-holes **93**, the ground plane **96** is positioned in the plane direction and circumferentially to the movement **140**. The conductive parts **91** contact the inside of the case **80**, and provide conductivity to the metal case **80**.

Five screw holes **141** are formed in the main plate **145**, and through-holes **92** are formed in the ground plane **96** at positions corresponding to the screw holes **141**. The through-holes **92** in the ground plane **96** are aligned with the screw holes **141** in the main plate **145** when the ground plane **96** is set provisionally to the main plate **145**. The plural screws **111** are then screwed into the screw holes **141**, and the ground plane **96** is firmly fastened to the main plate **145**. When the ground plane **96** is thus attached to the main plate **145**, the antenna studs **112** pass through the through-holes **93** and protrude vertically to the surface of the main plate **145** as shown in FIG. **11**.

Antenna cavities **42** that engage the antenna studs **112** are formed in the bottom of the antenna **40** as shown in FIG. **11**. When the antenna **40** is installed, the antenna studs **112** formed on the main plate **145** are engaged with the antenna cavities **42** in the antenna **40**.

The antenna studs **112** are cylindrical columns as shown in FIG. **10**, and the corresponding antenna cavities **42** in the antenna **40** are cylindrical holes. Therefore, by fitting the antenna studs **112** of the main plate **145** in the antenna cavities **42** of the antenna **40**, the antenna **40** is positioned in the plane direction to the main plate **145**, and the center of the movement **140** is aligned with the virtual center of the antenna **40**.

The antenna **40** is also positioned circumferentially to the main plate **145** by fitting the antenna studs **112** in the antenna cavities **42**. As a result, the antenna **40** is positioned in the plane direction and circumferentially to the main plate **145**.

The ground plane **96** also has hooks **94** that project up from the ground plane **96** at four locations. As shown in FIG. **12**B, each hook **94** has a through-hole **95**. Claw-like protrusions **41** are also formed to the antenna **40** at positions corresponding to the hooks **94** as shown in FIG. **12**A.

As shown in FIG. **10**, the main plate **145** has plural pedestals **113** as reference surfaces for vertically positioning the antenna **40** to the main plate **145**. The pedestals **113** are substantially round, and the top is parallel to the surface of the main plate **145**. The top of each pedestal **113** is at the same height relative to the surface of the main plate **145**.

Therefore, after the ground plane **96** is attached to the main plate **145**, and the antenna **40** is installed so that the antenna studs **112** of the main plate **145** engage the antenna cavities **42** of the antenna **40**, the bottom of the antenna **40** contacts the tops of the plural pedestals **113** as shown in FIG. **12**A.

FIG. **12**A shows the antenna **40**, a hook **94** of the ground plane **96**, and the main plate **145** in section, and FIG. **12**B is a view from the direction of arrow A in FIG. **12**A. As shown in FIG. **12**A and FIG. **12**B, when the antenna **40** is placed on the pedestals **113**, the through-holes **95** in the hooks **94** are not engaged with the protrusions **41** of the antenna **40**.

The hook **94** is then pushed up, that is, in the direction of arrow B in FIG. **13**A, and the top of the through-hole **95** in the hook **94** engages the matching protrusion **41** of the antenna **40** as shown in FIG. **13**B. As a result, the claw-like protrusion **41** protrudes to the outside of the through-hole **95** in the hook **94** as shown in FIG. **13**A.

Because the ground plane **96** is fastened by screws **111** to the main plate **145** and is made of a flexible metal as described above, the antenna **40** engaged with the hooks **94** is urged toward the main plate **145**, that is, in the direction of arrow C in FIG. **13**A, and pressed against the pedestals **113**, by lifting the hooks **94** up in the direction of arrow B as shown in FIG. **13**A. The antenna **40** is thus reliably positioned vertically to the main plate **145**.

As shown in FIG. **11**, the dial ring **83** is disposed vertically above the antenna **40**. More specifically, dial ring cavities **83***a* are formed in the bottom of the dial ring **83** as top member cavities that engage the dial ring studs **115** as shown in FIG. **11**. When installing the dial ring **83**, the dial ring studs **115** disposed to the main plate **145** are engaged in the dial ring cavities **83***a*.

The dial ring studs **115** are top member protrusions formed protruding vertically from the main plate **145**, are round columns as shown in FIG. **10**, and the matching dial ring cavities **83***a* are cylindrically shaped. Therefore, by fitting the dial ring studs **115** to the dial ring cavities **83***a*, the dial ring **83** is positioned to the main plate **145** in the plane direction, and the center of the main plate **145** is aligned with the virtual center of the dial ring **83**. The dial ring **83** is also positioned circumferentially to the main plate **145** by fitting the dial ring cavities **83***a* onto the dial ring studs **115**. The dial ring **83** is thus positioned in the plane direction and circumferentially to the main plate **145**.

As shown in FIG. **11**, the dial ring studs **115** and antenna studs **112** are disposed so that the length in the radial direction from the center of the dial ring stud **115** to the center of the antenna stud **112** is a specific distance G**2**. This distance G**2** is set so that the gap **43** between the antenna **40** and the dial ring **83** is a specific distance G**1** when the antenna **40** and dial ring **83** are engaged with the main plate **145**.

The configuration for positioning the antenna **40** in this embodiment of the invention thus disposes the antenna **40** in a compartment enclosed by the dial ring **83** and the bezel **82** with a specific distance G**1** to the dial ring **83**.

D. Benefits of the Embodiment

The antenna **40** and dial ring **83** in this embodiment of the invention are positioned relative to the movement **140** by engagement of the antenna studs **112** and dial ring studs **115**. The antenna studs **112** and dial ring studs **115** are formed in unison from the main plate **145** of the movement **140** with a specific distance G**2** therebetween in the radial direction maintaining a distance G**1** between the antenna **40** and dial ring **83**. Variation in the relative positions of the antenna **40** and dial ring **83** can therefore be suppressed. As a result, the effect of the dial ring **83** on the antenna **40** can be held constant, and good antenna reception performance can be maintained.

The antenna **40** is disposed in a space enclosed by the dial ring **83** and bezel **82**, and when the timepiece is subject to shock or vibration, the position of the antenna **40** in this space may change.

In this embodiment, however, the distance from the position where a hook **94** of the ground plane **96** engages a protrusion **41** of the antenna **40**, to the position where the ground plane **96** is attached to the main plate **145** of the movement **140** by a screw **111**, is set to a specific gap in the circumferential direction of the main plate **145** of the movement **140**.

Flexibility can therefore be imparted to the ground plane **96**, and the antenna **40** can be urged by the flexibility of the ground plane **96** so that the antenna **40** returns to the original position when the antenna **40** is displaced vertically by impact or vibration.

The distance G**1** between the antenna **40** and dial ring **83** is set in a range where the ground plane **96** remains flexible. More specifically, when the antenna **40** is displaced from the normal position, the top of the antenna **40** contacts the bottom of the dial ring **83**.

Because the distance G**1** between the antenna **40** and dial ring **83** is set so that the ground plane **96** is flexible even when the top of the antenna **40** contacts the bottom of the dial ring **83**, the antenna **40** can be returned to the normal state by the elasticity of the ground plane **96** without the ground plane **96** being plastically deformed. Impact on the antenna **40** can therefore be alleviated, and damage to the antenna **40** can be reliably prevented.

As described above, this embodiment of the invention can keep the effect of the dial ring **83** on the antenna **40** constant, and maintain good antenna reception performance, even when a plastic or other dial ring is disposed close to the top of the antenna **40** vertically. Furthermore, when the timepiece is subject to shock or vibration, damage to the antenna **40** in the antenna compartment can be reliably prevented.

The number of screw holes **141**, antenna studs **112**, pedestals **113**, and dial ring studs **115** in the foregoing embodiment is merely one example, but the invention is not so limited and the numbers can be desirably increased or decreased. The ground plane **96** is also not limited to being metal, and any elastic material can be used.

A ring-shaped ground plane is described in the foregoing embodiment, but the ground plane could be divided desirably into sections that are separately attached to the movement.

The above embodiment describes using hooks with through-holes therein, but the hooks do not need to be shaped this way, and any desirable configuration enabling engaging protrusions **41** on the antenna can be used.

E. Other Embodiments

The invention is not limited to the foregoing embodiments, and can be varied in many ways. FIG. **14** is a side view of an electronic timepiece **300** according to another embodiment of the invention, and FIG. **15** is a section view showing the fastening structure of this electronic timepiece **300**. Like parts in this and the first embodiment are identified by like reference numerals, the function thereof is the same unless otherwise stated, and further description thereof is omitted below.

The movement **110** and circuit bridge **130** are separate members in the first embodiment described above, and the circuit bridge **130** is used for positioning vertically to the timepiece. This embodiment of the invention renders the movement **110** and circuit bridge **130** in unison, and uses a spacer **150** that is separate from the movement **110** for positioning vertically to the timepiece.

As shown in FIG. **14**, the structure for fastening the movement **110** in this embodiment of the invention includes the main plate **120***a* of the movement **110**, the circuit bridge **130**, the spacer **150**, and the body **81**. The main plate **120***a* of the movement **110** and the circuit bridge **130** are formed in unison, and are made of a hard material with a specific strength.

The spacer **150** is disposed between the main plate **120***a* and circuit bridge **130** and the body **81**. The spacer **150** positions the main plate **120***a* to the case **80**, and is a member that is softer and more flexible than the main plate **120***a*. To position the main plate **120***a* horizontally to the body **81**, the spacer **150** has a spacer outside diameter engaging part **151** that contacts the horizontal positioning surface **81***a*, and a spacer inside diameter positioning surface **142** that contacts the movement outside diameter engaging part **123** disposed to the outside surface of the main plate **120***a*, as shown in FIG. **15**.

When the spacer **150** is inserted between the main plate **120***a* and body **81**, the movement outside diameter engaging part **123** contacts the spacer inside diameter positioning surface **142**, the spacer outside diameter engaging part **151** contacts the horizontal positioning surface **81***a*, and the spacer outside diameter engaging part **151** is pushed to the outside. As a result, the main plate **120***a* is positioned horizontally to the body **81**.

To position the main plate **120***a* to the body **81** vertically, the spacer **150** has a spacer lifter **144** that engages the back cover **85** and pushes the movement to the face side, and a movement lifter **143** that contacts the bottom **124** of the main plate **120***a* at the shoulder of the main plate **120***a*. Similarly to the upward pressure part **131**, the spacer lifter **144** also has protrusions that project down. The movement top positioning part **122** that contacts the vertical positioning surface **81***b* of the case **80** is disposed on the main plate **120***a* side.

When the main plate **120***a* is placed inside the body **81**, and the back cover **85** is attached from the back cover **85** side opening of the body **81**, the protruding part fits into the pressure channel **85***b* of the back cover **85**. The spacer lifter **144** transfers reaction from the back cover **85** to the main plate **120***a* when the body **81** is fit onto the main plate **120***a* on the back cover **85**, the spacer lifter **144** is pushed up (in), and the movement lifter **143** pushes up on the bottom **124** resting thereon.

When the movement lifter **143** pushes the bottom **124** up, the movement top positioning part **122** at the top is pushed against the vertical positioning surface **81***b* of the body **81**, and the main plate **120***a* is positioned and fixed vertically to the body **81**. As a result, a constant gap can be held between the antenna **40** and the case **80**, the effect of the case **80** can be kept constant, and good antenna reception performance can be maintained.

In addition, because the spacer **150** is made from a different material than the main plate **120***a*, the pliability to reaction from the back cover **85**, and the strength required to secure the movement, can be controlled, and the ease and freedom of design can be improved.

Although the present invention has been described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims, unless they depart therefrom.

The entire disclosures of Japanese Patent Application Nos. 2012-209029, filed Sep. 24, 2012 and 2012-209031, filed Sep. 24, 2012 are expressly incorporated by reference herein.

What is claimed is:

1. An electronic timepiece with internal antenna, comprising:

a tubular outside case;

a time display unit that displays time inside the case;

a back cover that closes a case opening on the opposite side as the display side of the time display unit;

a movement including a drive mechanism that drives the time display unit and a main plate that supports the drive mechanism;

a vertical positioning surface being a portion of the case that projects in the radial direction of the case on the inside of the case; and

an annular antenna that is held inside the case and is positioned relative to the movement;

the main plate having an upward pressure part that engages the back cover and lifts the movement to the time display side, and

a movement top positioning part being a portion of the main plate that contacts the vertical positioning surface and positions the movement vertically to the case when the upward pressure part lifts the movement to the time display side.

2. The electronic timepiece with internal antenna described in claim **1**, wherein:

a horizontal positioning surface is formed on the inside surface of the outside case; and

a movement outside diameter engaging part that contacts the horizontal positioning surface and determines the horizontal position relative to the outside case is formed on the main plate.

3. The electronic timepiece with internal antenna described in claim **1**, wherein:

the main plate includes a first member made of a hard material disposed on the face side of the time display unit, and a second member made of a softer material than the first member and disposed on the back cover side, the movement outside diameter engaging part and movement top positioning part being disposed to the first member, and the upward pressure part being disposed to the second member.

4. The electronic timepiece with internal antenna described in claim **1**, wherein:

the upward pressure part is formed by a member separate from the main plate.

5. The electronic timepiece with internal antenna described in claim **4**, wherein:

the upward pressure part is disposed between the main plate and the outside case, and includes

a spacer outside diameter engaging part that contacts the horizontal positioning surface formed on the inside of the outside case,

a spacer inside diameter positioning surface that contacts a movement outside diameter engaging part disposed to the outside surface of the main plate,

a spacer lifter that engages the back cover and lifts the movement to the time display side, and

a movement lifter that contacts a shoulder formed on the outside surface of the main plate.

6. The electronic timepiece with internal antenna described in claim **1**, wherein:

the antenna receives signals from a positioning information satellite; and

the movement is driven to display time based on the received signals.

7. An electronic timepiece with internal antenna, comprising:

a tubular outside case;

a movement housed inside the outside case and including a drive mechanism that drives a time display unit and a main plate that supports the drive mechanism;

an annular antenna that is held inside the outside case;

a top member that is disposed above the antenna and covers the antenna, and is separate from the main plate;

an antenna engaging part that positions the antenna relative to the movement; and

a top member engaging part that positions the top member relative to the movement;

the antenna engaging part and the top member engaging part being formed with the main plate.

8. The electronic timepiece with internal antenna described in claim **7**, wherein:

the antenna engaging part positions and prevents the antenna from moving horizontally and circumferentially to the main plate; and the top member engaging part positions and prevents the top member from moving horizontally and circumferentially to the main plate.

9. The electronic timepiece with internal antenna described in claim **7**, wherein:

the antenna engaging part has an antenna protrusion formed protruding vertically from the main plate; and

the antenna has an antenna cavity that engages the antenna protrusion.

10. The electronic timepiece with internal antenna described in claim **7**, wherein:

the top member engaging part has a top member protrusion formed protruding vertically from the main plate; and

the top member has a top member cavity that engages the top member protrusion.

11. The electronic timepiece with internal antenna described in claim **7**, wherein:

the top member is a dial ring that has an annular shape corresponding to the shape of the antenna.

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